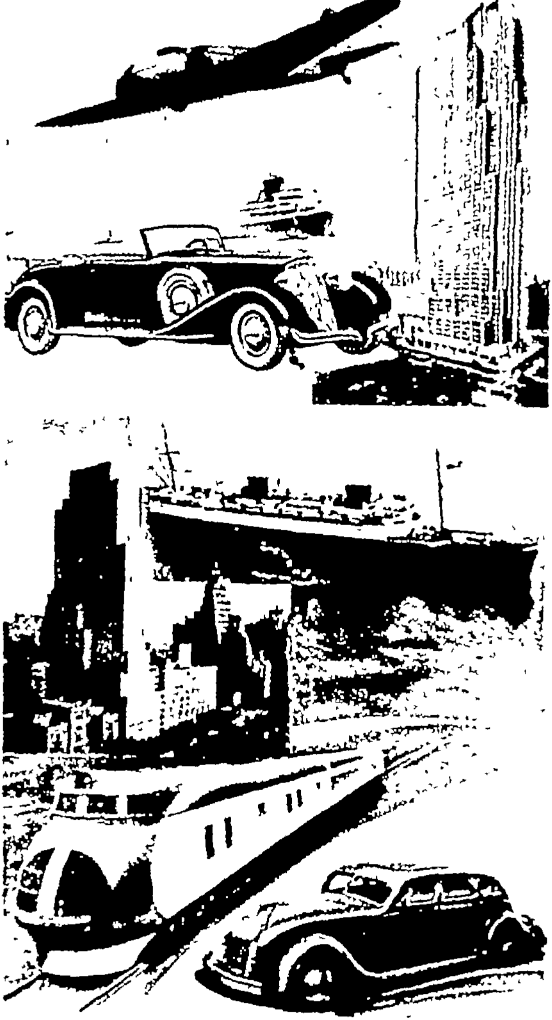
WONDER BOOK
OF THE
WORLD'S PROGRESS

VOL. X

INDUSTRIES • TODAY

INDEX



TODAY

WONDER BOOK
OF THE
WORLD'S PROGRESS

By
HENRY SMITH WILLIAMS

IN TEN VOLUMES
Illustrated

•

VOLUME X

Industries Today

FUNK & WAGNALLS COMPANY
NEW YORK AND LONDON

CONTENTS — VOL. X

INDUSTRIES • TODAY
INDEX

INTRODUCTION

THIS concluding volume of the series deals in part with varied aspects of material civilization as represented by mechanical accomplishment in the industrial world But we shall not altogether overlook the industrial conditions of the past (of which we have seen a good deal in earlier volumes), and for the imaginative mind the contrast between .present and past conditions gives at least intimations of possible developments of the future. Our chief concern, however, is with existing conditions, and in particular with the newest developments of the mechanical devices by which, in the opinion of the casual observer, the progress of civilization is to be gaged.

The most elementary analysis shows that the industries of today are basically the same as the industries of yesterday—and of all the yesterdays back to the very beginning of man's activities as a civilized being. The production, the manufacture, and the distribution of commodities—these are the three basic conditions to be met. For primitive man, production implied fishing, hunting, and the gathering of edible substances of natural origin, vegetable or animal. Manufacture had to do with the making of crude implements; the preparation of material for clothing and ornaments; and the construction of primitive dwellings. Distribution implied the making of crude boats and primitive land vehicles

In modern industry, fishing is still important, but hunting has been reduced to the status of a sport or

INTRODUCTION

THIS concluding volume of the series deals in part with varied aspects of material civilization as represented by mechanical accomplishment in the industrial world. But we shall not altogether overlook the industrial conditions of the past (of which we have seen a good deal in earlier volumes), and for the imaginative mind the contrast between present and past conditions gives at least intimations of possible developments of the future. Our chief concern, however, is with existing conditions, and in particular with the newest developments of the mechanical devices by which, in the opinion of the casual observer, the progress of civilization is to be gaged.

The most elementary analysis shows that the industries of today are basically the same as the industries of yesterday—and of all the yesterdays back to the very beginning of man's activities as a civilized being. The production, the manufacture, and the distribution of commodities—these are the three basic conditions to be met. For primitive man, production implied fishing, hunting, and the gathering of edible substances of natural origin, vegetable or animal. Manufacture had to do with the making of crude implements; the preparation of material for clothing and ornaments; and the construction of primitive dwellings Distribution implied the making of crude boats and primitive land vehicles.

In modern industry, fishing is still important, but hunting has been reduced to the status of a sport or

recreation. Agriculture and mining, basic industries on which civilization itself was founded, are still preeminent. Not until our own generation, when nitrogen was extracted from the air to make soil-fertilizer on one hand and explosives on the other, has the basic material for any kind of manufacture been available save as a product of the soil or of the mineral or subaqueous depths.

No morsel of food, for example, has ever hitherto been created elsewhere than in the green leaves and cellular tissue of plants.

The chlorophyl of the green leaf extracts carbon dioxid from the air and combines it with water to form basic sugars and starch. No human laboratory worker has as yet been able to duplicate this miraculous achievement All that man does is to provide favorable conditions under which the plant can work. That is the essential function of the agriculturist. The way in which he does this constitutes the story of the agricultural industry.

Similarly the mineral products that are basic in manufacture are supplied by nature, whether at the earth's surface or in the depth of rocky strata, and the varied mining industries have to do with the gathering of the natural materials and their manipulation, usually with a view to the isolation of elementary substances—copper, iron, gold, silver, and the rest. By exception, minerals are extracted from sea water (salt, magnesia) or from the substance of plants on land (alkai, charcoal) or in the sea (iodin).

With the basic products thus supplied by agriculture, mining, and lumbering, the manufacturing industries deal, to the ultimate end of feeding, clothing, housing the race, and meeting recreational and decorative needs and desires.

Meantime the distribution of commodities, whether crude or manufactured, and the transportation of animals and men, afford opportunity for the development of yet another series of industries involving, in the modern world, vehicles and craft of land, water, and the air.

All this implies, as suggested, merely the elaboration of mechanisms to meet basic needs that do not differ essentially today from the basic needs of our prehistoric ancestors.

In the matter of the communication of ideas, however, which may be classed as a form of distribution, there are elements which were at most only vaguely adumbrated in the experience of our prehistoric forebears. Primitive man signaled by beating drums or by visual signs (waving torches, smoke, flags); modern man sends messages by word or picture along wires or through the ether to the confines of the earth.

No one needs to be told of the great industries that have developed in connection with the communication of ideas by telegraph, telephone, and radio; nor of the allied communication through the medium of the "silver screen." The industries associated with these enterprises are essentially developments of our own time.

Another form of communication, as represented by the printed word, is of older origin, but the elaborated printing presses that make possible the production of newspapers, magazines, and books by the million are among the most significant mechanical devices of our own day.

All this seems very elemental, because it concerns matters of every-day experience. Yet these modern mechanisms through which the practicalities of the industries have been revolutionized are no less wonderful because they are familiar. Our pictures will show many

types of these mechanisms, in their newest forms of development.

In the concluding section I have struck a more directly personal note, making application of present-day medical science to the needs of the individual. Since the value of all cultural knowledge is, in the last analysis, to be appraised for its capacity to add to the welfare or happiness of mankind, it seemed appropriate to make such an interpretation. In so doing I have drawn on two of my very recent books, *Why Die Before Your Time?* and *Drugs Against Men*, through courtesy of the publishers, Robert M. McBride & Company.

My obligation to various publishers for permission to draw freely upon material of my earlier books was expressed at the outset. I wish to express a sense of double obligation, however, to Mr. McBride and to Simon & Schuster, publishers of *The Great Astronomers*, because the books just mentioned are of recent issue and are available in popular editions—whereas most others of my books from which I have drawn material for the present series—notably *The History of Science*, *The History of the Art of Writing*, and *The Historians' History of the World*, which together comprise no fewer than forty volumes—are of necessity out of reach of the average book buyer.

I may add that the inaccessibility of my larger sets of books has led me to draw on their contents with a special satisfaction. In particular is this true of the reproduction of facsimile plates from *The History of the Art of Writing*, to which reference was previously made. Most satisfying of all, however, has been the opportunity to bring together material from so many sources, giving the gist of fifty years of experience and investigation, into a unified series of books for the widest possible audience.

"ARTIFICIAL LIGHTNING"

I

SOME EVERY-DAY MYSTERIES

THIS series of books as a whole, dealing with the progress of thought and of man's interpretation of natural phenomena, has had to do with an unending sequence of events which were mysteries until solved, however commonplace they might seem thereafter It is not necessary here to recapitulate, even by name, these mysteries, nor is it desirable to enter into an elaborate analysis of unsolved problems.

It may be desirable, however, to give very brief but explicit attention to a few of the exceedingly familiar phenomena of every-day experience the explanation of which is not always readily forthcoming. As regards a good many of these, indeed, no very satisfactory explanation can be given.

Thus the most familiar of all phenomena, the action of universal gravitation, is a profound mystery. No one knows why a lead pencil, for example, when you drop it, falls to the floor instead of rising to the ceiling Not infrequently, when we offer explanations of observed phenomena, the explanation does not really get to the heart of the matter, but only pushes back the veil of mystery one stage farther.

If, for example, one were to ask why we sneeze, why we yawn, why yawning is catching, why scratching the skin relieves itching, and what is the real character of itching itself, we can give only tentative answers, which involve questions of the transmission of impressions

along nerves to the brain; reactions in the brain itself; and other impulses sent out along nerves from the brain. And while it is easily possible to make the answers sufficiently technical to seem profound, in reality they amount to little more than the statement that such reactions have been developed because each in its way is beneficial to the individual, and therefore beneficial to the race. To call the process "reflex action" is to name rather than to explain it.

Similarly the question where thoughts come from, so often asked by children, can be answered properly enough by saying they originate in the brain, through coordination of sensations. A psychological treatise might be written in explication of this statement, but after all is said and done the fact of the origination of thought in the brain is a profound mystery. The mechanisms of brain cells and connecting fibrils entering into the genesis of thought can be fully described and illustrated. But thought itself, tho perfectly familiar to everyone from his own experience, eludes definition or complete understanding

We define rather than explain these mysteries Nevertheless, in the ordinary use of language, such definitions may be accounted explanations. For only in that sense can we explain such other phenomena as magnetism, the electric current, the emission of light by incandescent substances, muscular action, and a host of others.

On the other hand, there are many mysteries of the world about us which to casual observations seem equally inscrutable, which are no longer mysteries in the sense of being unexplained by scientific investigators. A host of these, as already suggested, have been brought to our attention as we studied the progress of knowledge from the earliest time to our own day. It should not be over-

looked, however, that there are numberless physical phenomena whose very familiarity makes us take them for granted, yet which are found puzzling if we are called on to explain them in definite terms.

Why, for instance, does the wind blow? It was declared of old that no man knows whence the wind comes nor whither it goeth Today this statement hardly holds. We know that the wind comes from regions where the air has been cooled and goes toward regions where the heated air has risen with a suction effect. But if you press the matter as to why heated air rises, there is no final answer forthcoming — because the question of weight involves that inscrutable problem of gravitation.

Again, the direction of the prevailing air currents is influenced by the whirling globe and the inertia of every physical substance. But inertia itself is inexplicable.

In general, it may be said that the explanation of the forces of nature is on a different plane from the interpretation of the character of the matter on which the forces operate. Thus, while we do not know the actual nature of the forces of gravitation and inertia which combine to make our earth globular in form and determine the phenomena of winds, for example; yet we are able to analyze the soil and name its constituents, and to say with full confidence that the atmosphere consists of little-varying proportions of oxygen and nitrogen, with a varying amount of water vapor, and infinitesimal but highly important increments of carbon dioxid, ammonia, and sundry "impurities" We can even establish with a good deal of certitude the chemical nature of the constituents of the earth's interior. We know, for example, that oxygen is the most abundant constituent of the rocky matter of the earth's crust.

But *why* oxygen and nitrogen and carbon dioxid are

gases at "ordinary" temperatures, yet become liquid or solids at other temperatures, we do not know. Why oxygen and hydrogen, gaseous when free, assume the liquid state when chemically combined, is a deep mystery.

In a word, then, the ultimate *whys* are beyond our ken. But this does not prevent us from utilizing the half-understood forces and principles. In particular, there are possible new applications of familiar principles, constituting novel practical inventions. Such applications are being made every day. And the field of future possible inventions is inexhaustible.

I once amused myself by suggesting a series of possible extensions of inventive ingenuity into several practical fields, and published the fantasies in a popular magazine, the *American,* under the rather spectacular title, "Six Ways to Make a Billion Dollars." I do not know that I can better suggest some of the opportunties that lie just ahead than by reproducing the article here, slightly modified. Meantime a series of pictures showing some of the very new achievements in the field of the practical industries will serve as suggestive and stimulative background—partly because they represent actualities that are quite as wonderful as the potential discoveries specifically suggested in the text.

II

TAPPING ATOMIC ENERGY — A FANTASY

LET me suggest that before you start to read this chapter you get a glass of water and put it in front of you.

My object is not to quench your thirst, but to stimulate your imagination I shall ask you to see in that glass of water only things that are known to be there—things no less actual because they are invisible to the naked eye. And I shall attempt to show you how these infinitesimal habitants of the water give clues to billion-dollar opportunities.

Yes; it was *billion*-dollar I said, not mere million-dollar opportunities. If you can learn to juggle the contents of that glass of water in just the right way, you may count with full confidence on getting a billion dollars for your secret. Indeed, this understates the case, for there are *more billion-dollar ideas than one in the glass*, as I *shall show you presently.*

One world at a time, however. Our first concern is not so much with the water itself as with the energy that is stored in it. Yet this is perhaps a distinction without a difference, since energy and matter, in the last analysis, appear to be but two sides of one shield. At any rate, it will soon be clear that, while we *seek* working energy, we must *talk* constantly about atoms of matter, especially about hydrogen, which, as you know, is one of the two constituents of the molecule of water.

The hydrogen atom is, indeed, the djinn that is to show you where the billion-dollar purse is hidden.

The secret is that the hydrogen atom carries an amazing store of energy, part of which it is willing to dispose of under certain conditions I will give you a formula which, by implication, tells what those conditions are.

It may be stated thus: "In each molecule of water in this tumbler, two hydrogen atoms are held captive by a big oxygen atom. If you will liberate these captives, and permit them to join, four by four, to form helium atoms, you will learn something to your advantage."

That's all there is to it. And if you can devise a practical plan for doing this on a commercial scale, I assure you there will be no trouble at all about forming a syndicate to give you a billion for your process for making helium out of hydrogen.

Helium, as you doubtless know, is an extremely valuable gas exceedingly useful for filling balloons, because it is not inflammable. You are therefore to make helium, and nothing else; yet the helium, after it is made, will be only a by-product—the smoke that goes up the chimney, as it were.

The really valuable product that your invention offers is working energy.

When any atom, or any molecule, combines with one or more other atoms or molecules, a relatively enormous amount of energy is released. But in this regard there is no other atom at all in the class of hydrogen. The energy released when any four hydrogen atoms are permitted to join together to form an atom of helium is simply prodigious.

Let me illustrate. The tumbler of water before you contains roughly 20,000,000,000,000,000,000,000,000 hydrogen atoms. If these hydrogen atoms were made into helium, the energy resulting would have the effective heating power of 4,800 *tons* of coal; or, to put it an-

other way, this energy gradually released would be sufficient to propel the *Leviathan* across the ocean at full speed, no other fuel whatsoever being required.

Why, the hydrogen in any teaspoonful of water will generate 100,000 kilowatt hours of electrical energy, or 133,000 horse-power!

And any single drop of the water, if its hydrogen were recklessly made into helium all at once, would explode with the force of a two-pound stick of dynamite

Incredible? Yet perfectly true. And there isn't any "catch" in it, either. The hydrogen-helium trick is simply waiting for someone to turn it.

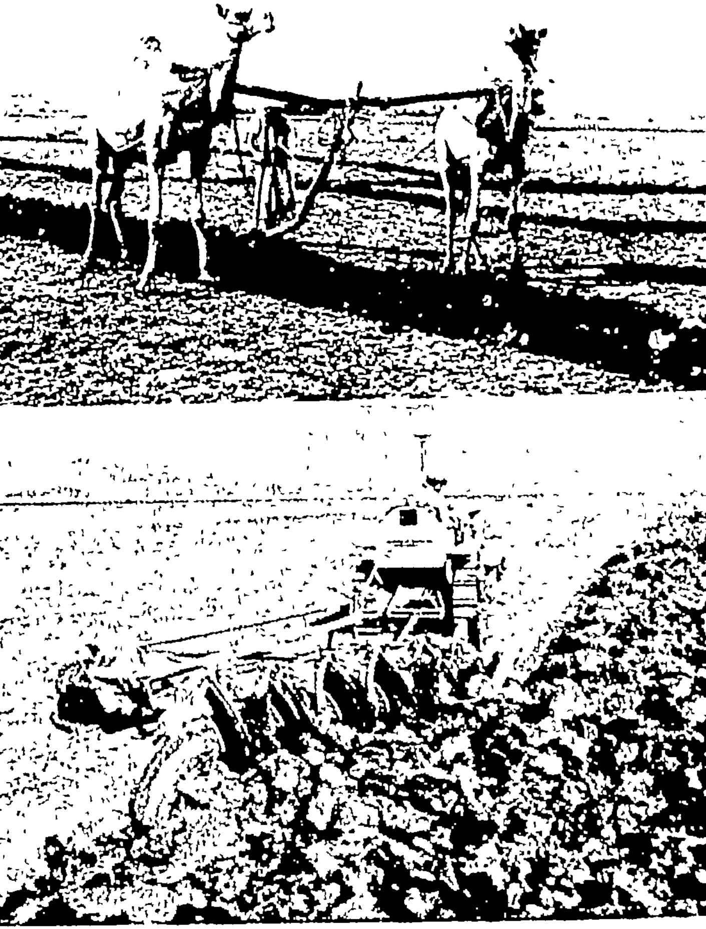
The only difficulty is this: When you liberate the hydrogen atoms from their oxygen bondage, as may readily be done with an electric current, they will be able, under ordinary conditions, to unite only two by two But this won't do. You must make the conditions such that they can unite four by four.

The difference may not seem to you very material. But, from the atomic standpoint, it is so material that your reward (in units of energy) will be a *trillion* times greater for permitting the four-by-four combination than it will be if you permit only the two-by-two combination.

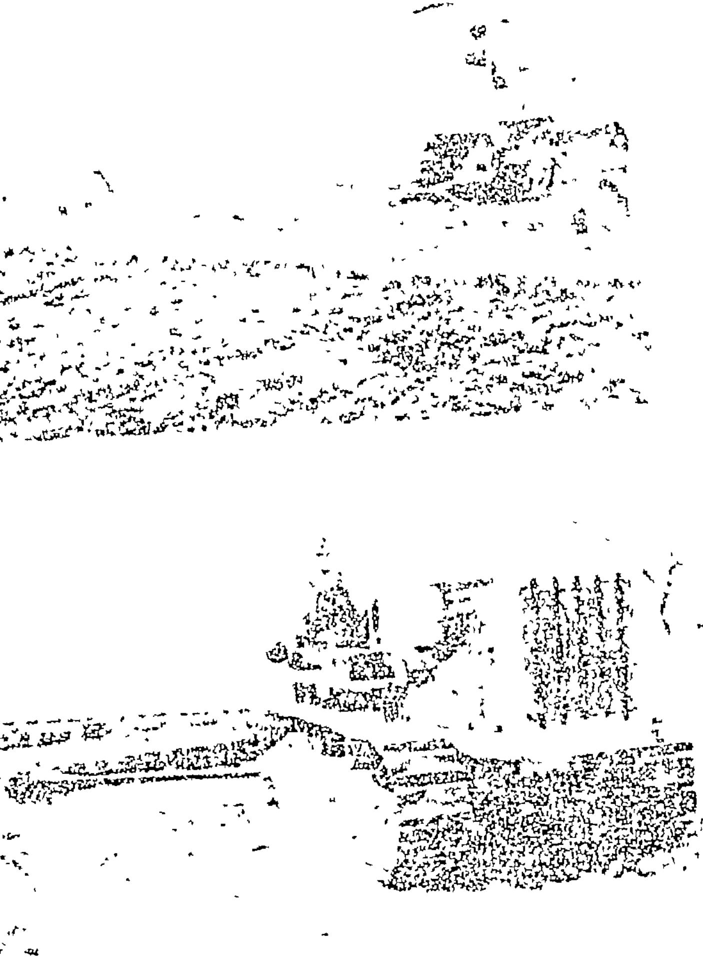
In practical terms, the hydrogen atoms in a teaspoonful of water, released and permitted to join two by two, will give you the heat-equivalent of a pea-sized pellet of coal. The same hydrogen atoms, permitted to join four by four, will give the heat of one hundred *tons* of coal

Can this bewildering discrepancy be explained? It can—at least provisionally. And thereby hangs the billion-dollar tale I am telling. Its essence is this:

When two hydrogen atoms unite, it is a tame affair, when four are permitted to get together, the reunion is



EGYPTIAN AND AMERICAN PLOWING



so riotous that a portion of the very world-stuff of which they were created is annihilated!

Can this be proved? Very simply. Every hydrogen atom by itself weighs exactly 1.008 atomic units. Two hydrogen atoms, united, weigh just twice that. But do four hydrogen atoms, joined to make an atom of helium, weigh four times 1 008? They do *not*: they are short weight by .032 atomic units. Quite the strangest disappearance ever recorded in cosmic or other history has taken place About three-fourths of one per cent of the very substance of the four hydrogen units has been dissipated, apparently into nothingness. A miracle has happened!

Let us delve into the heart of this mystery The hydrogen atom consists of two unit particles: the *proton* and the *electron*, the two being held in the grip of electrical and magnetic forces. The proton, however, has the weighable substance of 1,845 electrons. Practically, the total mass of the hydrogen atom is, therefore, proton-substance.

When four hydrogen atoms (four pairs of protons and electrons) unite to form a helium atom, it is mostly protonic substance that is missing

Where did the missing proton matter, the essence of world-stuff, go? That is the mystery. And fortunately it is solvable--so, at least, the modern physicist believes. The missing proton matter has been changed into *energy* —basic, primordial, fundamental energy; call it *protonic* or subatomic energy, if you will, to indicate that it comes from the very heart of the atom.

So, when you induce four hydrogen atoms to unite to form an atom of helium, you are tapping the abysmal depths of the infinite storehouse of cosmic energy.

It is an experience in itself awesome; in its conse-

quences, stupendous. For from each group of hydrogen atoms harnessed four by four, you will get a *trillion* times the energy that was ever obtained from a like mass of matter under human control in any furnace or engine or dynamo or device whatsoever, since the world began.

Your helium machine (when it is invented) portends a new era in civilization! No longer will you be dealing with mere molecules, as in a steam engine, or with interchange of atoms, as in a gas engine, or with the fairy flight of electrons from the power-house generator; but with the colossal power of the basic, primordial particles that are the unit structures of all the matter and all the cosmic energy in the universe.

Dare one tamper with such unthinkable power? Pounds of dynamite in a drop of water! The strength of a hundred thousand horses in a teaspoon! A power-house generator in a tumbler!

How release such energies, and escape destruction?

Theoretically, the answer is this: release them gradually. Nature gives the cue when she makes water rise as a vapor. The atoms in your tumbler *individually* are nothing to brag about. It is union, and the correct union at that, that gives them strength.

Even as you sit there looking into the tumbler, billions on billions of water molecules, each freighted with two atoms of hydrogen, are jumping up from the surface of the water, and hurtling off into air. And when a single drop of water has thus evaporated and mingled with the air, every cubic millimeter (pin-head size) of space in the atmosphere of the entire fifteen-foot room in which you sit, will contain upward of a hundred billion of the molecules that a few minutes ago were water in the tumbler, and now are no less water because they have assumed the guise of vapor.

There you have the clue.

A drop of water, even a fine spray of water, you dare not attempt to handle for your experiment. But a few cubic millimeters of vapor-laden air might with safety be introduced into a strong compression chamber — perhaps the cylinder of an automobile engine—in which you are to conduct your hydrogen-helium experiments.

Suppose you put about ten drops of water into the empty gasoline tank to evaporate. Small whiffs of this vapor-laden air, introduced through the carburetor, may be further diluted with absolutely dry air, or with an inert gas (a gas that contains no hydrogen).

Now, all you have to do is to discover an agent that will strip the proton of the hydrogen atom of its electron mate, thus disturbing the electric balance and modifying the tense magnetic field that constitutes the atom's protective shield. Robbed of their mates, the most natural thing in the world—nay, the inevitable thing—is for four hydrogen atoms to rush into mutual compact, thereby constituting themselves a helium atom, and giving out a glorious offering of cosmic energy in the form of usable, and salable, heat

Millions of tons of helium are probably thus being made in the atmosphere above your head. Why not a few atoms in your machine?

The *molecular* outburst in a big steam engine gives a thrust of many hundred pounds to the square inch. The *inter-atomic* explosion in a gasoline engine produces heat enough to drive your car with the power of ten, fifty, a hundred horses. The *sub-atomic,* or *protonic* detonation in your helium-spark engine will liberate the power of a thousand horses—or a hundred thousand. There is no limit, except as imposed by the strength of your spark chamber

Harness your hydrogen atoms four by four, and you make coal and fuel-oil potentially obsolete You make the vapor of water the universal fuel—with atmospheric air as the practical source of supply

Just think of it! No fuel required but water-vapor for furnaces of every type; for power-house generators; for the engines of steamships, locomotives, automobiles, airplanes, and dirigibles; to heat dwellings, operate local electric plants, and drive farm machinery.

Coal and oil in the discard! Mines that produced a billion tons of coal last year, and oil wells that spouted a billion barrels, put out of business by that yet more abundant gift of nature—water! It is a vision to dazzle the eyes of prophetic imagination.

Will it ever be more than a vision? Why not? Hydrogen-helium power is no more visionary today than the idea of making steam do the world's work seemed in the year 1800; no more visionary than the idea of making an electric current do the work of horses seemed in 1850; no more visionary than the idea of talking hundreds of miles over a wire seemed in 1870; or the idea of wireless control of a ship or car, in 1890.

It is not a thousandth part so fantastic as the crazy dream that whiffs of gasoline, whirling canoe blades, might lift great vehicles into the air and make them fly like birds above the clouds, seemed in the year 1900.

It is no such fantasy as the familiar facts of the X-ray, or radio broadcasting.

The idea of the helium engine seems fantastic only because it is new. Not till yesterday did we learn anything about the interior of the atom. One of these days it will seem as natural to lure power from vapor, by the hydrogen-helium route, as to get power out of steam or exploding gasoline.

THE AGE OLD CRADLE - EARLIEST REAPER IN AMERICA

tents, is clear and transparent. It would still remain so if, by waving a magic wand, you were to cause each carbon atom in a portion of the water to forsake its oxygen mates and link itself with a molecule of water. (A molecule of water being, as you are well aware, two hydrogen atoms held captive by one oxygen atom.) Yet every family group of six carbon atoms combined with six molecules of water would constitute one molecule of the kind of sugar called glucose.

And if you were to take out a spoonful of the sirup that the tumbler now holds, and—again by waving your wand—remove a single molecule of water from each molecule of the sugar, what remained would be starch, and the water would become turbid

Another spoonful of the sirup might be treated in a different way By splitting each sugar molecule in half, and adding to each moiety two atoms of hydrogen, you have a molecule of glycerin. The sirup of a third spoonful may have its molecules of sugar modified by removal *of two carbon atoms and two atoms each of hydrogen* and oxygen, to form butyric acid.

By mixing glycerin with the butyric acid—in just the right way, of course—you produce a fat which is the equivalent of butter.

Thus, by a little juggling with the molecules of water and carbon dioxid originally in the tumbler, you have sugar and starch, and butter And there is no limit to the other kinds of sugar and fat and oil that would result from further manipulation of the same materials. You could even make such substances as cellulose, wood pulp, and paper, if you chose, for carbon, hydrogen, and oxygen are the components of all of these.

If the supply of carbon atoms were to give out, you have but to take a straw, put it into the water, and

bubble your breath through it For the carbon dioxid you exhale will be absorbed by the water and give additional experimental material.

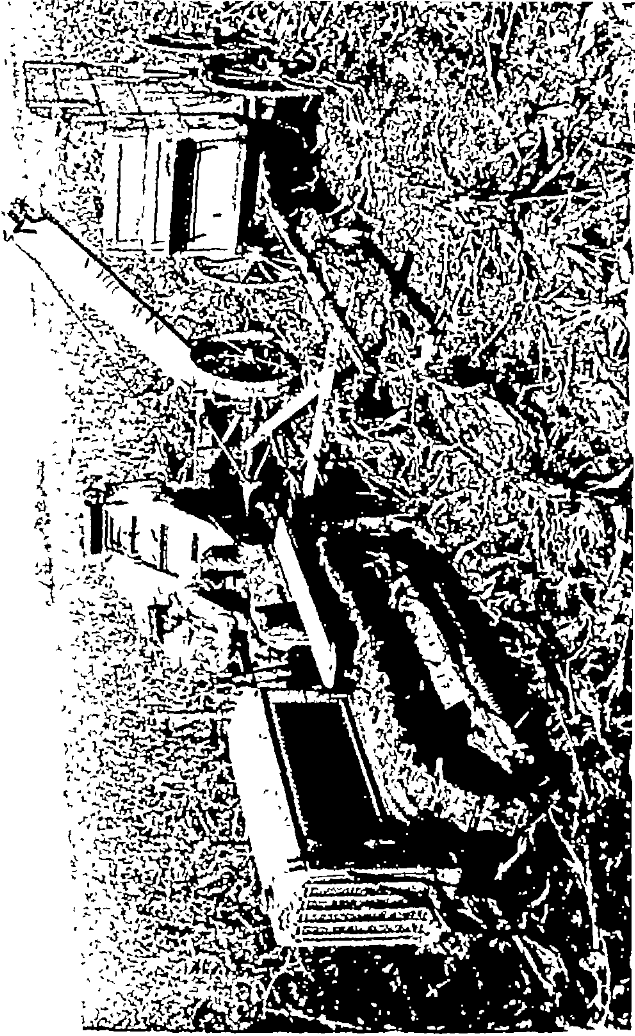
Absolutely pure, distilled water, plus your breath, would supply all the material needed for making a cracker, and butter to spread on it; or a portion of tapioca, and the sugar and cream to serve with it; namely, carbon, hydrogen, and oxygen.

Nor need you stop at that: Another pass or two of the magic wand, and you may have a whole-wheat bread sandwich, with cheese or egg or beef for filling. You will first combine two molecules of water with two atoms of carbon and then add a single atom of nitrogen, a constituent of the air in the water that you have hitherto neglected, *not needing it for any carbohydrate or fat.*

This new combination of two atoms of carbon, four of hydrogen, two of oxygen, and one of nitrogen will give you the simplest form of "amino-acid," named *glycin* You have *only to add increasing numbers of* carbon, hydrogen, and oxygen atoms (and, toward the last, one more nitrogen atom), to make in sequence all the other amino-acids, about seventeen in number. And these are the building stones of which every molecule of albumen or protein is compounded

And protein, as of course you know, is the veritable life-substance. No living cell or tissue, vegetable or animal, has any basis but protein. So, by mixing together variously the different amino-acids you have made, you may gain wheat protein for your slice of bread, or milk protein for the cheese sandwich, or egg protein, chicken-meat protein, beef protein—what you will

To make the proteins quite complete, you must, to be sure, have added a few atoms of sulfur, and sometimes an atom or two of phosphorus, to the large groups of



PICKING CORN BY MACHINERY

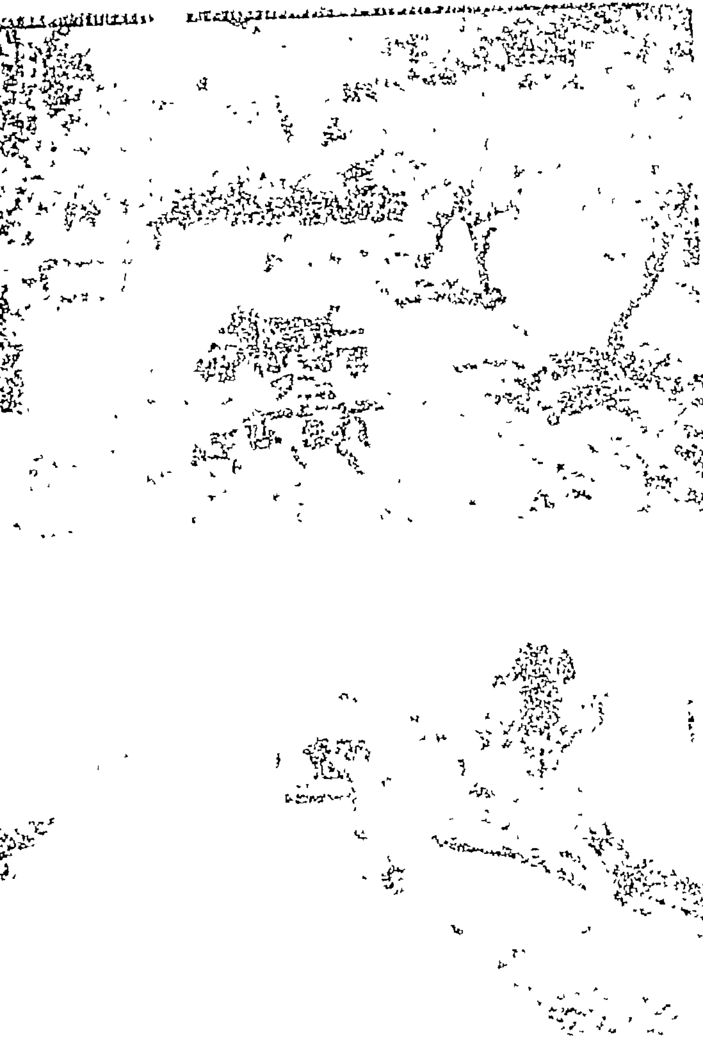
carbon, hydrogen, oxygen, and nitrogen atoms making up the bulk of the structure But these are supplied from the "traces" of sulfates and phosphates of magnesium and sodium in the water So are various other minerals that enter into the structure of vegetable and animal tissues—tho not entering into the composition of sugars, starches, fats or proteins themselves

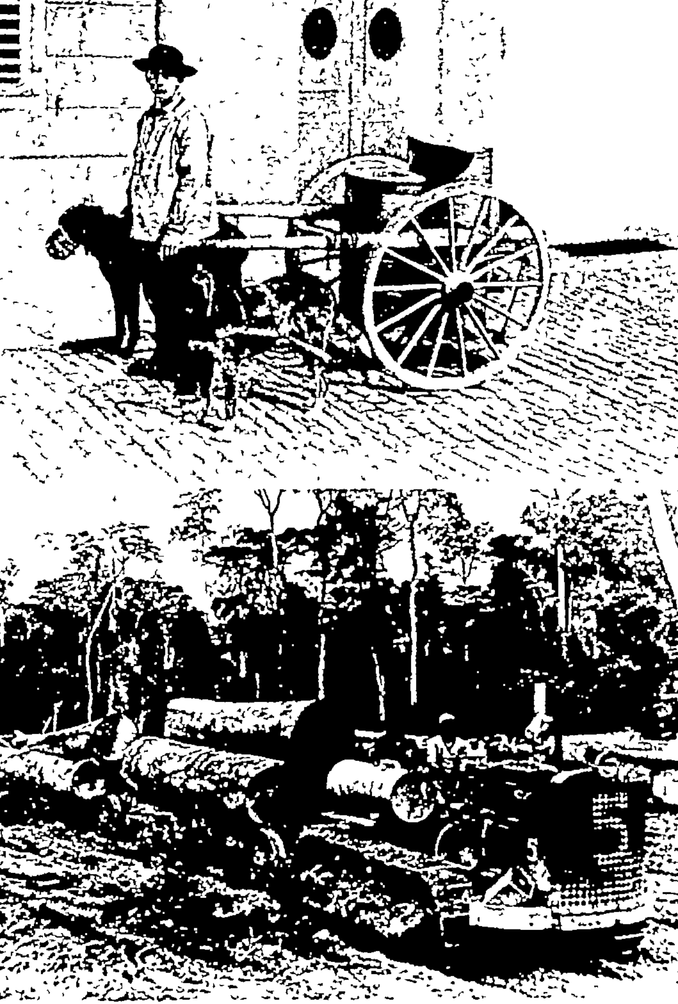
Vegetable fiber contains silicon; traces of this element are always dissolved by water from the substance of any glass receptacle in which it is held Even if your tumbler of water has been certified by a chemist as pure and unadulterated, it contains, as we have seen, all the constituents of a very palatable and nourishing lunch, garnished, if you wish, with salads or vegetables or fruits, and completed with a portion of apple pie *à la mode*

Of course the *quantity* of material in the tumbler might prove inadequate; but then you can always go to the tap or well for another helping of water.

All this sounds most inviting But what about the magic wand with which to do these miracles? Ah, there's the rub. The constituents are there in the tumbler. Some day—can we doubt it?—science will learn how to combine them in laboratory and factory Perhaps not in our generation, but surely some time

[illegible] GASOLINE TRACTION





FROM DOG CART TO CATERPILLAR TRACTOR

IV

A DREAM OF HARNESSED TIDES

PERHAPS, however, your mind runs to the mechanical rather than to the chemical side of invention. Very well. Here is a mechanical problem that is good for ten-figure money—if you solve it I mean the problem of tidal power.

All the oceans of the world rise and fall twice every day with irresistible power. Why has this power been wasted while men dig into the earth for coal and put wheels under puny waterfalls?

Not altogether for lack of human effort, for since the day that King Canute failed to make the tide obey him, hundreds of patents have been taken out for tide machines.

More than that, many of the devices thus patented work—after a fashion There is a small tide machine in the river Thames near London today that has been in operation for over a hundred and thirty years.

The feasibility of harnessing the tides at certain places is so well understood that the French Government has under way a project to develop a 5,000 horse-power plant near Brest. England contemplates a $150,000,000 development in the Severn estuary; and the State of Maine a few years ago ratified a bill to develop tidal power in the Bay of Fundy, to cost $100,000,000, which is expected annually to produce the equivalent of power from ten million dollars' worth of coal.

In the tide-reservoir systems as contemplated in the

Bay of Fundy and elsewhere, the gates are shut after the water has flowed in, and power is gained by letting the water flow out, operating turbine wheels meanwhile, as the tide recedes. Part of the power thus gained may be used to pump some of the basin water into higher reservoirs, to be used to operate other turbines as it flows back again.

All this might seem to suggest that the problem of tidal power had been solved. Far from it. These installations, however successful, will represent only a crude beginning. In fact, the principle of operation is no different from the primitive tide machine installed in the Thames in 1790.

Of course interesting details of modern engineering will be involved; but the "basin" system that is to be utilized is available on a large scale only where the tides average at least ten feet. There are but few places along the coasts of our entire continent where tidal plants of this character could be economically installed

Now, the tidal machine that I have in mind calls for something quite different from this. It must utilize tides that rise only four or five feet, and it must be available along every shore, in every harbor. It should be adjustable to every floating wharf and to every ship that docks

Consider the conditions: The *Leviathan*, let us say, with displacement of not far from sixty-five thousand tons, is at her dock in the North River. Twice each day her enormous bulk is lifted, with the average tide, about four and a half feet, and allowed to settle back again. If she is docked for five days, she has been lifted forty-five feet into the air—and allowed to drop from that height. And this is equivalent to the hoisting of one thousand tons of metal to more than half a mile, and dropping it from that altitude.

That surely is something to reflect about: The *Leviathan*, alongside her pier, occupies only one hundred feet of shore line; the coast of Manhattan Island stretches mile after mile, so it is clear that millions of horse-power go unbridled along this water front, to say nothing of the waste along the far greater stretches of the harbor as a whole.

What manner of tide machine could be devised to make this colossal power usable? In general terms, the answer is simple: What is required is an apparatus that can transform the *energy* of the slowly moving tides into a form that could be stored and accumulated, or transmitted, for practical working use.

Of course, gigantic pistons, geared to wheels, could readily enough be attached to floating docks, or ships in harbor; or friction devices could be made to turn this mass motion, caused by the tides, into heat But a storage vault for the heat is quite lacking, and storage vaults for electricity are costly and inefficient.

Compressed-air systems have been tested, but can hardly be made available on a large commercial scale. A slow-motion electric generator, in combination with a cheap and really efficient electric storage-battery system, is perhaps the clue to this billion-dollar puzzle.

Incidentally, the perfected storage battery would have many and obvious uses for the storage of power generated by other forms of prime movers One of the greatest problems of every public-utility power plant is to meet the fluctuating demand for the current it supplies —since the current must be used in the very moment of its production. Your perfected storage battery will be welcomed by generating plants that now produce and distribute annually no less than sixty-six billion kilowatt hours of electrical power.

But even that, in the present view, is only incidental. Your real opportunity lies in the development of a *new* motive force, in large measure to *supplant* the power systems of today, rather than to aid them. When costly coal is burned to generate electricity, 84 per cent of its potential power is lost; and the incandescent-light bulb wastes 95 per cent of the residual power that comes to it

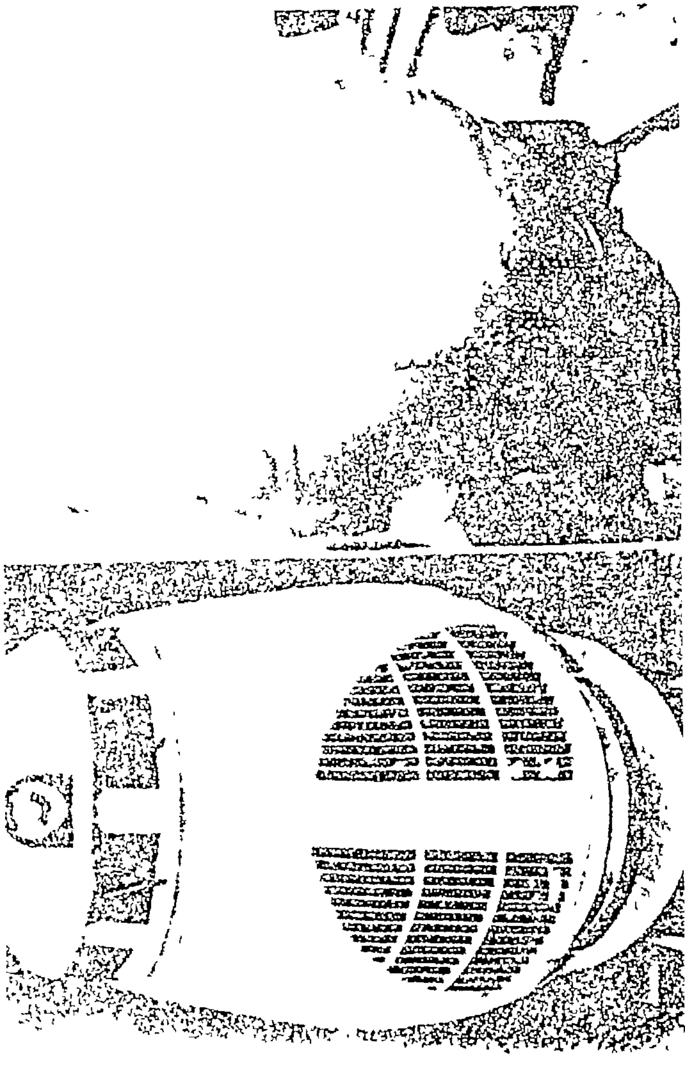
Waterfalls are limited in number and in power. All told, if developed fully, they would supply but a fraction of the electric power required.

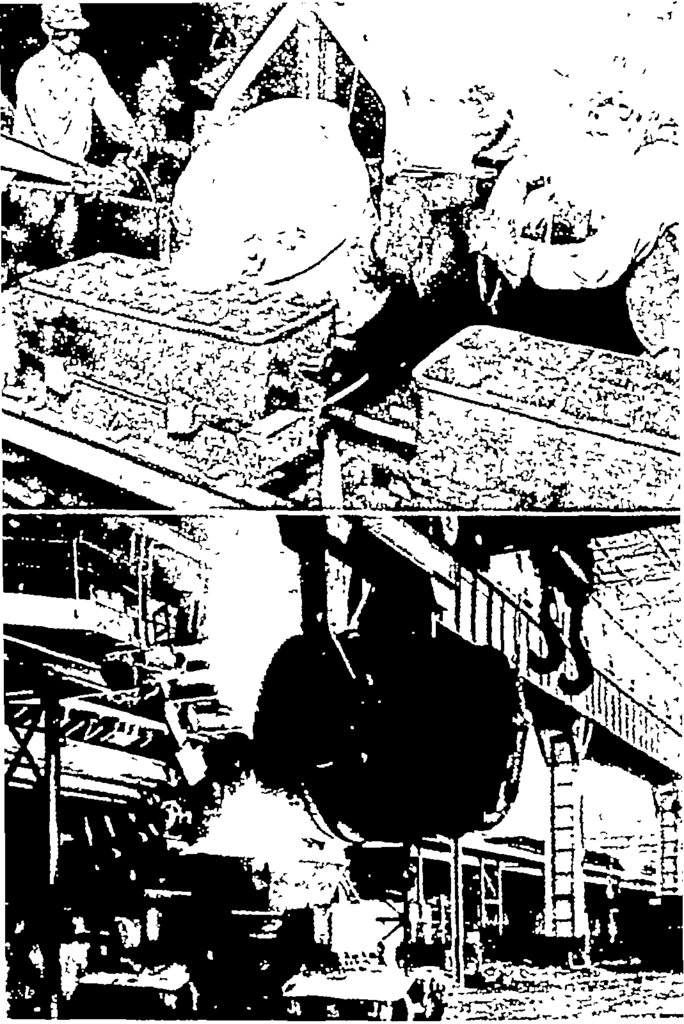
The big modern power plants are being built at the mouths of the coal mines, and the power there wastefully produced is wastefully transmitted hundreds of miles to the seaboards, where incalculable and inexhaustible supplies of energy go absolutely to waste with every oscillation of the tides

All this will be changed when the problem of a really effective tide machine is solved You need not be a seaside dweller to tackle the problem The secret may just as well be sought in a workshop a thousand miles away from salt water. When it is found, and not before, water in motion will outrival coal as a source of working power

OPENING THE FIRST TRANSCONTINENTAL RAILWAY

A HALF CENTURY LATER





MANUFACTURE POURING STEEL

V

THE ONE-WAY HEAT PROBLEM

MEANTIME, it is not impossible that coal, as a heat giver or motive force, may be challenged successfully from a quite different quarter. If a material could be found, or developed, that would transmit heat in one direction only, the challenge would be mandatory. That statement reveals the next billion-dollar opportunity I wish to bring to your attention.

A one-way heat material! That, you say, is a pipe dream. It calls for a substance having attributes of the miraculous.

Even so, let us not abandon the dream without further challenge. Let us get back to our glass of water for experimental purposes. Suppose we imagine that the tumbler is made of such material, transmitting heat inward. Cover it tightly, and the water will boil presently as it stands there on the table It would still boil—tho not so soon, if you had packed the tumbler in ice.

Now, pour the boiling water into another receptacle of the same material, but reversed, so that the heat travels only outward. Put this receptacle of boiling water over the fire, if you wish. That will not keep it from freezing, ultimately.

Boiling water on ice and freezing it over the fire would be novel experiences. Yet that could happen, if you invented a one-way-heating substance!

Just think of its uses: You could cover your walls with it and your house will be cool in summer With

the material reversed, it will heat itself in winter, regardless of outside weather—quite without fuel. No sudden changes, but a gradual and cumulative effect.

Receptacles made of this material would serve either for fireless cookers or ice-cream freezers. Incandescent light bulbs would need no electricity if made of one-way-heat glass. Tho glowing with light, they would be *perfectly cool to the touch; yet a metallic rod, blown into* the bulb (which incidentally need not be a vacuum), might be exteriorly attached to an otherwise fuelless grid. Holding the bulb in your hand, you could use the metal for a soldering iron.

Here, among other things, would be one solution of the problem of cold light. The light-giving substance would not be cold, of course; but its heat would be shut in.

Is any such magic one-way-heat material known? Of course not. I am suggesting that you make a billion dollars by inventing such a material. Conceivably, it might be done by the electric or magnetic treatment of some material—or of many materials, so as to make the substance transmit heat in one direction or the opposite, alternately, at will of the manipulator, as we can reverse the flow of an electric current.

On a larger scale, the material would serve to make a steam boiler, for example, that would operate without a furnace, actuated only by heat from the atmosphere; accentuated, if conditions permitted, by direct rays of the sun.

Do you see the billion dollars in such a material? In *this country alone it would supplant half a billion tons* of coal.

The clues? They bristle in any modern presentation of the interrelations of energy and matter. Heat may be

regarded as the basic, primordial energy, which manifests itself as static electricity and magnetism in the intimate relations of protons and electrons; as chemical affinity in the interplay of atoms; as "temperature" in the interplay of molecules.

We may measure all energies in terms of heat; and discuss heat in terms of matter. Professor Eddington tells us quite casually that the sun is giving out 120 billion *tons* of heat annually (Incidentally, it is supposed to be heat liberated by the hydrogen-helium process.) Another physicist suggests that sunlight perhaps creates 80,000 tons of matter (protons and electrons) annually here at the earth's surface.

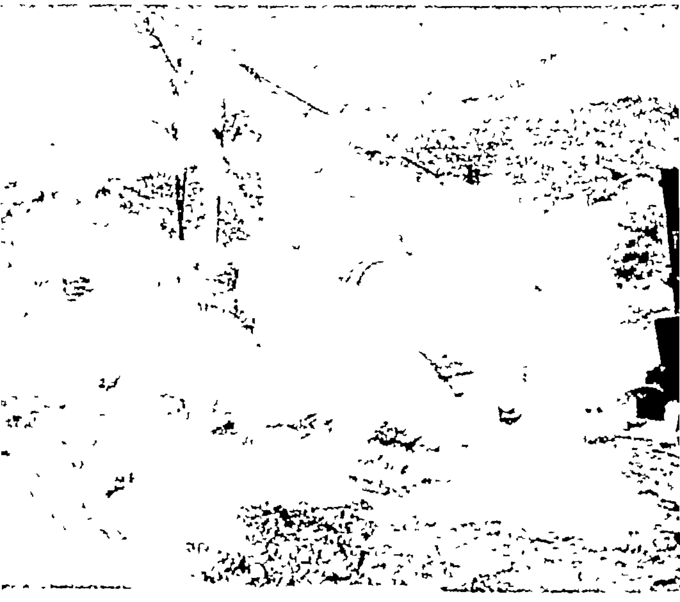
Sir J. J Thomson, discoverer of the electron, conceives that energy which is the equivalent of heat may be transmitted in a solid by the sliding of chains of electrons between rows of atoms arranged in the form of a lattice of crystal-like structure. Might not the direction of such "sliding" be controlled, as we control the electron-flight we call an electric current?

The fact that the "crystal detector" of the simplest radio receiver appears to let energy through in certain planes, and in one direction only, offers a worth-while clue.

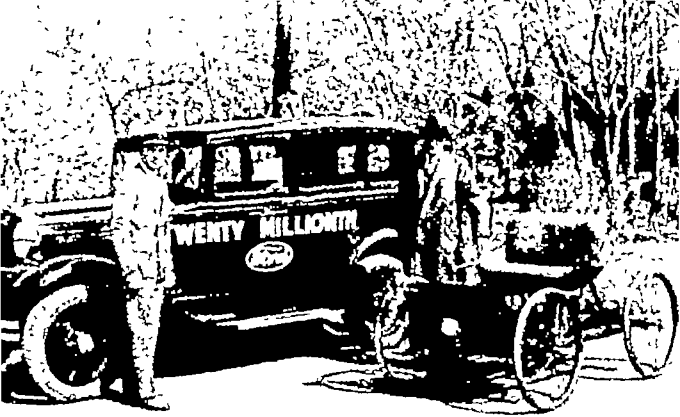
A dozen years or so ago, a schoolboy in Yonkers observed certain curious fluctuations in the receiving power of his home-made wireless apparatus. He induced a relative to bear the expense of taking out a patent on the improved circuit he was led to devise A few years later the lad was famous as Major Armstrong, discoverer of the "feed-back" circuit; and it was currently reported that his first royalty check, after his boyhood patent had been validated in the courts, was for a half-million dollars.

I, for one, shall not be surprized if some lad who today is similarly experimenting with a home-made radio set should ferret out a relation between electric currents and heat transmission that eventuates in the discovery of a one-way-heat material or method, the basic patent on which outvalues all the radio patents in existence, a hundred to one

A pipe dream! Perhaps But all great inventions were pipe dreams at first.



THE TRACTOR AS HANDY-MAN



THE FIRST TWENTY MILLION

A GOOD START ON THE SECOND

VI

FACTORY-MADE GOLD

MEANTIME, there are other possibilities, quite different, but no less alluring, for which the study of your radio apparatus might put you in training The making of a billion dollars' worth or so of the most merchantable of all commodities, gold itself, is among them. For the old problem of the alchemists is no longer a scientific heresy.

On the contrary, the newest discoveries in physics make it clear that the creation of gold by transmutation is theoretically possible, even probable Moreover, they reveal the precise changes by which allied elements, notably mercury, thallium, and lead, might be transformed into gold.

Large atoms are built up, it appears, chiefly of helium atoms, but these in turn, as we know, are made of hydrogen atoms, each of which consists solely of one proton and one electron. *In the last analysis, then, atoms may be considered as made solely of protons and electrons.*

All atoms are built on the same plan—a nucleus and an orbital region. All the protons are in the nucleus, and about half of these (in large atoms many more than half) are closely bound with electron mates It helps one better to visualize the conditions if one thinks of these as married protons, living with their wives at the heart of the atomic colony.

The remaining protons, unmated, may be thought of as a colony of bachelor protons, surrounding the mar-

ried quarters The number of bachelor protons in any atom determines absolutely the rank of the element, and, with that, the physical and chemical properties it presents.

For each bachelor proton, there is one spinster electron in the outer orbit, circling at a distance, in a course of prescribed character, like the orbits of the earth and the other planets about the sun One or more of these spinster orbital electrons may be temporarily driven outside its atomic orbit without changing the essential character of the atom

But if a bachelor proton moves out of his colony there is an amazing transformation.

To illustrate: There are exactly eighty bachelor protons in the nuclear colony of every mercury atom in the world. The residents of the married colony, on the other hand, may vary to the extent of at least six couples without affecting the atomic status. But the loss of a single bachelor proton would change the mercury atom into gold; for any atom with seventy-nine bachelor protons is the royal metal, and none other.

But note this curious yet theoretically explicable anomaly: whereas, one or more mated couples might migrate from the married colony without changing the atomic status, yet the defection of one mated electron would be disastrous to the atomic autonomy—for the reason that the deserted husband would immediately move out to the bachelor colony, and thus add one to that company. The erstwhile mercury atom, with eighty-one bachelor protons on guard, changes into thallium.

On the other hand, a similar marital misadventure in a gold colony will at once demote the gold atom into a mercury atom.

Yet another way in which a mercury atom might be

transformed into a gold atom would be by having a wandering spinster electron fly comet-wise near enough the nucleus to be seized on by a bachelor proton. After such marriage by capture, the newly-wedded pair would shift, naturally, to the married quarters, leaving only seventy-nine bachelors on guard—and thus again our mercury atom becomes gold

This by no means exhausts the atomic possibilities. If you could persuade an atom of lead to throw out an electron from its nucleus, to be followed by two helium nuclei, the lead would be transformed into pure gold.

Or perhaps you might prefer to make the assault from the other side, attempting to build up a smaller atom into gold, instead of tearing down a larger one. Conceivably, an iridium atom, in a helium atmosphere, amidst a tornado of electrons might have its magnetic conditions so disturbed that a helium nucleus would be swept into the iridium nucleus. Presto! No longer iridium, with seventy-seven bachelor protons, but gold, the royal metal; since the helium nucleus carried the two necessary bachelor protons that turned the trick.

Conceivably, whatever the other conditions, some catalytic agent must appear on the scene to cause the new chemical to combine and exercise the strangely persuasive influence of its kind. Some amateur radio-telegrapher, experimenting with high-frequency currents in various media, might accidentally discover such an agent, as Perkins discovered the secret of analin dyes when a student, while trying to make synthetic quinine; or as Nobel discovered the way to make dynamite, through the chance observation of the dripping of a few drops of carelessly spilled collodion on the clay floor of his workshop

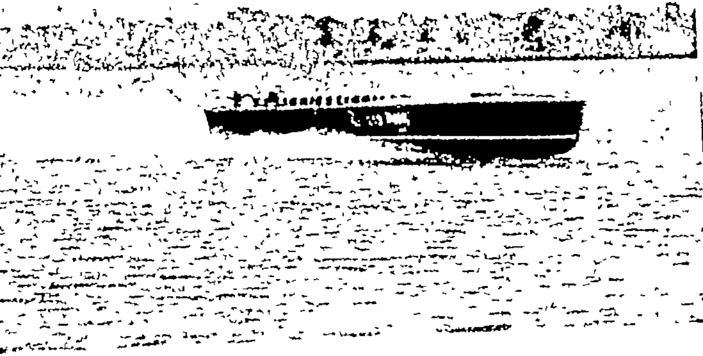
Each of these casual discoveries led to a billion-dollar

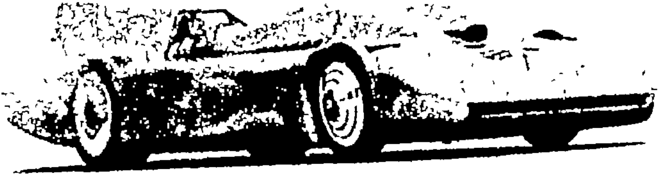
industry. But these industries had to be slowly developed. Salesmanship was required to back the genius of invention

With factory-made gold, the case would be quite different. You need but cart your manufactured gold to the mint, and by the process of stamping it becomes money.

As a matter of fact, it isn't necessary that you manufacture your gold or turn it into money. It will quite suffice to have discovered a method by which it *can* be manufactured, at a cost significantly less than the cost of mining natural gold. Prove that you can do this, and any government—even governments that are off the gold standard—will gladly give you a billion for your secret.

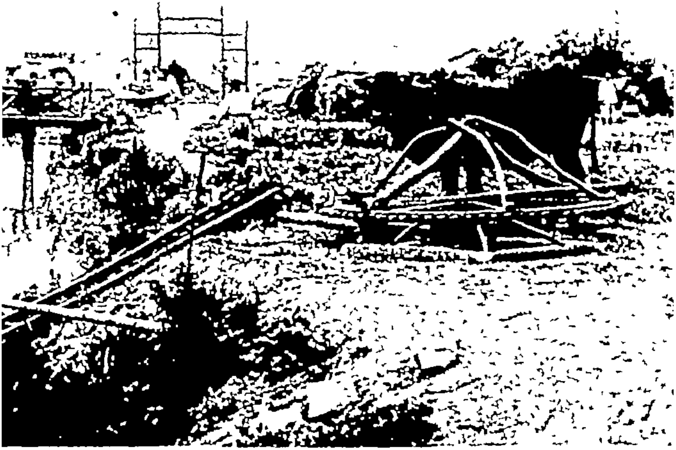
Of course all governments will abandon gold as the standard yardstick of values as rapidly as legislatures can be induced to function, after factory gold has flooded the market. But no such radical change as that can be achieved except by slow stages, You will have had your billion, and will have converted it into real property, long before the smash comes.

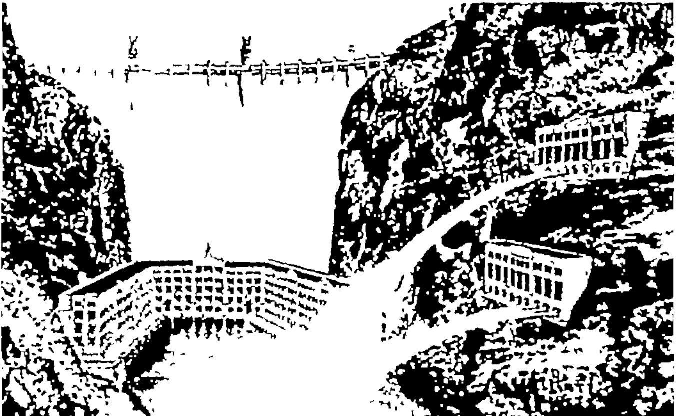




ONE HUNDRED MILES AN HOUR

FOUR AND A HALF MILES A MINUTE





ONE-OX POWER IRRIGATION IN CHINA

MILLIONS OF HORSE POWER AT HOOVER DAM

VII

DIGGING FOR HEAT

IT seems rather like an anticlimax to turn from atom juggling to work with even a glorified pick and shovel But there is one other billion-dollar opportunity so alluring that I must refer to it, even tho it concerns so prosaic a theme as the digging of a hole in the ground.

I refer to the project of tapping the inexhaustible supply of heat that awaits release from the depths of the earth's crust.

Everyone knows that the heat is there, but no one hitherto has shown us how to get in touch with it and let it do the major part of the world's work, as it well might.

We laboriously dig or bore into the shell of the earth to get a limited supply of fuel If we were to bore a little deeper, we might tap an inexhaustible supply of heat

Only a few thousand yards below the surface, the earth's interior is everywhere a caldron of fire, or its equivalent Mostly solid stone, no doubt; but stone so hot that it would turn water instantly into steam.

Fortunately, our oceans are now blanketed from this furnace, else the earth would be uninhabitable. But here and there a leak occurs, as witness hot springs, spouting geysers, and volcanoes in action The five-mile plume of steam that occasionally hangs above old Vesuvius signals a billion-dollar opportunity to all the world

Why has this opportunity been so long neglected?

Chiefly, I suspect, because the supply of coal was nearer to hand. Maybe, if our periodical coal strikes had been longer and more effective, old Mother Necessity would have taken a hand, and before now the coal mines would have been as much out of date as windmills and over-shot water-wheels.

Today men scramble for possession of million-dollar mines and oil wells, and quite ignore the billion-dollar furnace that lies beneath the meanest acre of the earth's surface—just as formerly they scrambled for million-dollar gold mines and neglected the billion-dollar aluminum deposits beneath their very feet.

Incidentally, the efforts of others to gain a lesser prize give clues to this greater prize. In digging for oil, men have developed tools and methods that have carried them half-way toward the goal.

The most successful oil drill has bored a hole to the depth of 7,745 feet. You have but to perfect a method of boring, say, twice as deep, and the world is your orange

When you "strike heat," you will tap a gusher potentially worth all the oil wells plus all the coal mines of the world. The first spout of steam from your heat-well will signal a new economic era

Oil wells that produce thirty billion gallons of fuel oil in this country alone in a year, and coal mines with an output of more than half a billion tons, will be potentially as much out of date as peat beds

You may drive your heat-well in the handiest corner of your back yard, wherever you live—and the cars of millionaire manufacturers or their representatives will block the highways as they crowd to your door to bid for the right to use your method.

Yours is the secret of inexhaustible power, with no

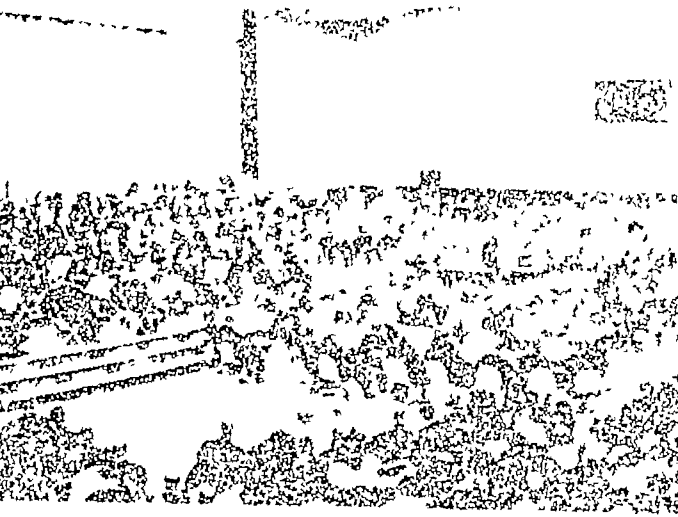
cost beyond that of first installation—a discovery that may well cut the cost of production in half for a thousand important industries; that may shift whole populations to new manufacturing centers, give the labor world a four-hour day and four-day week, and bring mankind a long step nearer the industrial millennium.

Let us pause on that note. After all, what is mere money, compared with the contribution to human health and happiness that such a discovery connotes? Look at the matter in that light, and no mischance could rob you of your reward.

If your basic patents held, you would be sure enough of the billion dollars But, in any event, you could count yourself, in the coin of human gratitude, at least a trillionaire.

Turn we now from these dreams of future possibilities to certain very salient practicalities of today

"ALL ABOARD!"



physical part of you. You can probably give a pretty good account of the essential parts of your motor car. Can you do as much for the vital organs of your own body? If you can, you are an unusual person. Yet it is very much worth while to know what *you* are like, and how you work, if you are to make an intelligent effort to keep yourself in health, and bid for length of years.

Let me, then, present a brief word picture of you, as you are seen through the eyes of a doctor who is (as most doctors are) something of a biologist and a student of evolution.

It may shock you a little (or more than that) to be told at the outset that the really important part of you, in the scheme of Nature, is a pair of small sex glands But we must not blink the truth. No other part of you has any real significance, by and for itself Every other part of you is designed to aid this one essential part in carrying out its function of race preservation. There is no other reason why you need a machine of bone and muscle to move you about in quest of food and a mate. Or why you need a digestive system to handle the food after you get it. Or a heart to pump blood to every corner of the body to nourish the remotest tissues. Or a brain to collect impressions and serve as chauffeur for the motor part of the body-machine that is you.

But, having made that clear, we need not further concern ourselves here with the sex glands. Our concern is with the body tissues which, even if subordinate, are absolutely essential, since the master tissue would be quite helpless without their aid. The machine of bone and muscle and digestive system and blood stream and heart, kidneys, lungs, brain, et cetera, is the apparatus I wish to depict. This is the part of You that I wish to bring clearly to your attention.

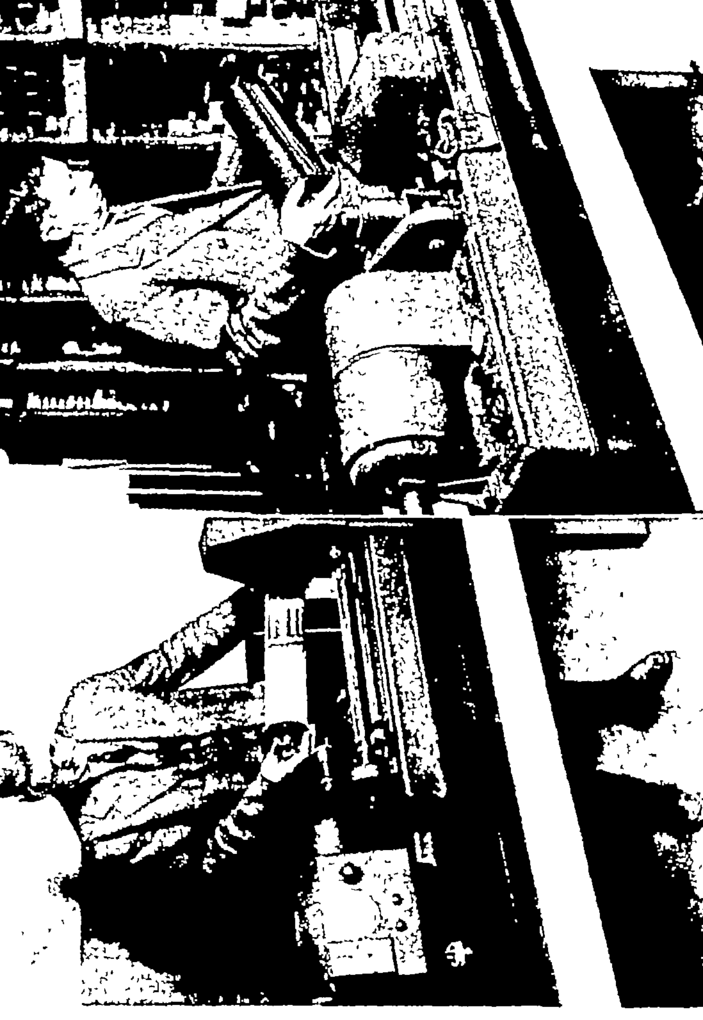
At the outset, note that this body has two points of contact with the outside world One is the outside skin, with its modified organs of special sense, the other is the inner skin, called mucous membrane, which lines the digestive tract. As these two surface coverings meet and join at the orifices, the two together make a complete garment in which your vital organs and tissues are encased.

If you lacked the protection of this glove-fitting outer and inner shield, you could not live a single day Myriads of germs would swarm into your living tissues and overwhelm them in a few hours. You are alive simply because, under ordinary circumstances, your skin and mucous membrane serve as an impregnable barrier against the invaders

The outer-skin surface of your body contains the pores of myriads of sweat glands, which excrete some waste products and serve a highly important function in radiating heat to cool the body But it absorbs little of anything. Even virulent poisons, if non-corrosive, may be rubbed against it harmlessly.

The inner-skin surface, or mucous membrane of the digestive tract, on the other hand, is highly absorbent of liquids. And it is provided with glands that have the power to liquefy solids of certain types, so that their substance may be absorbed into the blood stream and become a part of the body tissues themselves The glands that perform this function are called digestive glands. The substances they act upon are called foods. Many substances that are not foods may also be liquefied and absorbed. Some of these are poisonous to the living tissues when they come in contact with them. Some foods may generate poisons in the digestive tract under abnormal but not unusual conditions.


WINTER RELIEF
WINTER RELIEF



WIRE-PHOTO: TRANSMITTING AND RECEIVING CYLINDERS

Branching from the digestive tract, at the beginning of the throat, is a tube (called the trachea) which leads to another closed cavity that is divided into myriads of little saccules in the lungs. Here food of another type, the oxygen of the air we breathe, is absorbed into the blood stream, to mingle with the foodstuffs absorbed from the stomach and the intestinal walls. Jointly, the supplies from these two sources — lungs and digestive tract—furnish material for the body fires that supply energy and for the rebuilding of vital tissues as they wear away under action.

The lungs have a rather curious double function. Even as they supply oxygen to feed the body fires they are receiving from the blood and expelling from the body the familiar product of combustion called carbonic-acid gas. Were your lungs to fail, even for a single minute, to perform this double function, you would suffocate So imperative is the call for oxygen, and the need to get rid of the waste product, that your mind could not make your bellows —muscles of ribs and diaphragm— cease to operate the lungs, however hard it might try. Nature has not made the mistake of placing your life tenure at the discretion of any part of you.

Certain other waste products of combustion of your body tissues are carried by the blood to your kidneys and are there excreted in the urine. It is essential to life that these substances also should be promptly removed from your blood stream—just as ashes and clinkers must be removed from a furnace or combustion products from the cylinders of your automobile engine. The matter is so vital that two kidneys have been provided, either one of which could do the work. Should both become incapable of working, you could not continue to live. Needless to say, your conscious mind has no direct con

trol over the action of the kidneys. But sluggish action or diseased condition of these organs may clearly—and most unpleasantly—register effects on your mind—such as a sense of ill-being, pain, drowsiness or complete stupor.

Something about your heart you, of course, know. You are perhaps aware that it is a marvelous four-chambered pump, the left side of which handles arterial blood, oxygen-charged, from the lungs; while the right side receives venous blood from the tissues and propels it through the lungs You know also that the large arteries from the heart divide and branch into smaller and smaller tributaries, called arterioles, and finally into a meshwork of infinitely small capillaries that bathe the remotest cells of every tissue

The red corpuscles that carry oxygen are known to you at least by name And you have doubtless heard of one type of white corpuscles, or leucocytes, famed as the defensive army that guards your tissues against the invasion of microbes The four or five other types of white corpuscles you perhaps have hardly heard even named. Nor do you know much, probably, about the amazing factory, situated largely in the marrow of your bones, in which the red blood corpuscles are turned out at the rate of about one hundred billion per second of a 24-hour day.

In the eyes of the physiologist, the blood is a tissue It is a more liquid, and therefore more mobile, tissue than others, because that condition is necessary in order that it may perform its function of conveying materials of many kinds from one part of the body to another, thus forming a channel of communication between other tissues and the organs that they compose.

But the blood must not be thought of as merely a

liquid. Its watery part gives it mobility; but its physical and chemical functions are chiefly carried out by the parts of it that have structure, or solidarity. There are, for example, upward of three hundred quadrillion red blood corpuscles in the blood stream of an average-sized human being. Each of these is visible as an individual cell under low powers of the microscope. Each is an individual thing that has an independent life, being born in the bone marrow and going to ultimate dissolution in the liver; with an average life-period of about thirty days.

Lacking these corpuscles the blood could not function as the carrier of oxygen to the tissues; nor could the system free itself without their aid from sundry toxic products that in one way and another get into the body.

Then there are the white corpuscles; less numerous than the red, yet numbering several thousand to every cubic millimeter of blood. There are at least five types of these corpuscles, each, of course, with a definite function. Jointly they guard the body against the invasion of such foreign bodies as malignant bacteria. Some of them literally eat and digest microbes of disease that invade the body; others deal with invaders of different types, such as molecules of foreign proteins that are not supposed to get through the intestinal wall unbroken, but not infrequently do so and become poisonous agents against which the white corpuscles must give protection

On other occasions the white corpuscles are mobilized to attack obnoxious cellular tissues that develop within the body itself, and which would grow into cancerous masses if not nipped in the bud. On yet other occasions white corpuscles are mobilized at the site of an injury—say, a knife wound—to guard against bacterial invasion and to supply materials for repair and healing.

Each white corpuscle is in itself effectively a living organism, provided with a nucleus and capable of moving from place to place under its own power, so to speak. But the army of corpuscles as a whole could not be mobilized fast enough to meet emergencies were not the individuals swept along in the liquid blood stream. With precision that suggests intelligence, adequate millions of individuals leave the procession at the point where they are needed and mass themselves into platoons of defense. Their seemingly intelligent mobilization and mass movement suggests inevitably the activities of an army of defense.

The other constituents of the blood stream are not visible, even under the microscope, but may be revealed by chemical methods. Blood chemistry is of the utmost importance. The blood stream at one time or another contains every material that is used in the building or functioning of all tissues of the body; as well as every type of waste product that results from such functioning.

As a matter of course, the quantity and quality of some of the materials dissolved in the blood stream vary from hour to hour, if for no other reason than because we take food at intervals. While the digestion of a hearty meal is under way, the quantity of the products of digestion entering the blood stream naturally increases. Yet the change is not as rapid or as great as might perhaps be expected; both because of the relatively slow process of digestion and absorption and because of the relatively rapid handling of the food pabulum by the ultimate tissues. Cells in need of food quickly select the materials suited to their needs, and the organs of elimination promptly set about filtering the waste products out of the blood stream.

Prompt action in both respects is essential, as the

blood stream would otherwise become clogged with excess quantities of glucose, fatty acids and proteins, on the one hand, and urea, uric acid, creatinin and carbonic acid, on the other Even under normal conditions, a certain amount of overcrowding of the blood stream freightage does occur—as anyone who has felt drowsy after a hearty meal can testify from his own experience

The rapidity with which the tissues handle the foodstuffs supplied them and the degree of activity of the organs of elimination, as tested by chemical analysis of the blood under varied conditions of eating or fasting, furnish valuable diagnostic signs, records of average conditions of normal persons in health being, of course, available for comparison. Thus the amount of glucose in the blood stream gives definite clues to the condition of the interstitial cells of the pancreas, which secrete into the blood the hormone insulin, the regulator of sugar metabolism.

But while physical examination, especially with the microscope, and ordinary chemical analysis reveal numberless secrets of blood constitution in health and in disease, there are certain intimacies of personality, so to speak, that cannot thus be investigated A certain individual may have, for example, a so-called anaphylactic condition of "sensitization" to a particular type of protein, from having had a minute quantity of that protein introduced into his blood stream perhaps some years earlier No chemical test with conventional reagents would give a suggestion of modification of the blood: and yet the injection of a drop of a dilute solution of the protein in question may result in an almost instantaneous manifestation of toxic symptoms These symptoms may vary from such minor reflex acts as sneezing and yawning to intense pains and total collapse.

A food protein, like the casein of milk or the albumen of egg, may produce such sensitization. To the sensitized individual, this wholesome protein then takes on something of the quality of snake venom. Milder degrees of sensitization account for the susceptibility of some individuals to the pollen of plants (a protein substance) Of the same origin are the asthmatic attacks which some persons experience from eating this, that or the other protein food of unchallengeable general wholesomeness: or even from casual contact with the hair of a cat or feathers in a pillow, or the chance inhalation of dust bearing some infinitesimal trace of the particular protein which to that individual is anathema; or the pollen of plants, as in "hay fever."

Such phenomena suggest that very minute changes of blood or tissue may permanently modify a human personality. That the very life of an individual might hang on so slender a thread seems almost incredible, but there is other evidence of the appalling power of almost un*believably minute quantities of matter in operation on* the human organism.

Thus, tests show that a marked effect on the whole organism is shown when adrenalin, extracted from the suprarenal capsules, is introduced into the blood stream to the amount of one part in four hundred million. And it is said that a product has been isolated from the pituitary gland that is a thousand times more potent even than that. An ounce of this substance, Professor Hoskins estimates (borrowing, he says, an illustration from Ludin), would give potency to every drop of water in a series of 600-gallon tanks placed twenty feet apart for a distance of five thousand miles.

This sounds fantastic. But it is an estimate based on carefully devised tests on animals and supported by a

host of allied observations on the human patient. The influence of the hormones would be weird in any event; but the effects savor of magic when we note the absurd disproportion between the quantity of substance involved and the magnitude of its effects.

Thus Professor Hoskins is able to say of thyroxin, the essential hormone isolated from the thyroid gland, that "one grain of it would roughly cause any of us to live a third faster than we should in complete absence of the thyroid gland," adding that the total amount of thyroxin circulating in the body at one time is only about one-fourth of a grain, and that three and a half grains suffice to keep an individual in health for an entire year. "But this small pinch of thyroxin spells all the difference between imbecility and normal health."

As to the brain, which may fairly be called the organ of *thought*, even tho it be denied the title of exclusive organ of *mind*, two or three interesting things should be noted.

One is that the manner of distribution of the blood supply in the brain is unique. Each localized region is supplied by a meshwork of loops from a single arterial stem—in effect a closed circuit. As the arteries have the power to contract, the blood supply of one region may be greatly reduced in order that the supply of another region may be increased. So it would appear that, in order to flush all parts of the brain, activities of different types must sequentially be indulged. This perhaps explains the observation that versatility of mental application tends to give mental health and apparently conduces to length of life—as evidenced by the histories of a long list of notables who have lived into the eighties and nineties.

A second significant fact about the brain, somewhat

recently observed, is that it apparently never degenerates in such wise as to cause the type of mental impairment known as senile dementia (uncomplicated by syphilitic or alcoholic poisoning) except where the arteries have hardened—*thus making impossible the normal flexibility* of the cerebral circulation.

We learn that hardening of the arteries is one of the *consequences of certain infringements of the laws of* health. It is, in other words, a self-imposed condition. It has long been said, half facetiously, that a man is physically "as old as his arteries." In the light of the new inference it would appear that the saying has a force hitherto unsuspected. It begins to be apparent that the mental decay which has been supposed to be a natural concomitant of age is, instead, an evidence of physical abnormality

This observation, and the evidence given by hundreds of very old persons whose healthy arteries permit their minds to retain the vigor and resourcefulness of youth, *justifies the conclusion that you and I, if we live hygienically*, may confidently expect to retain full mental vigor as long as we live.

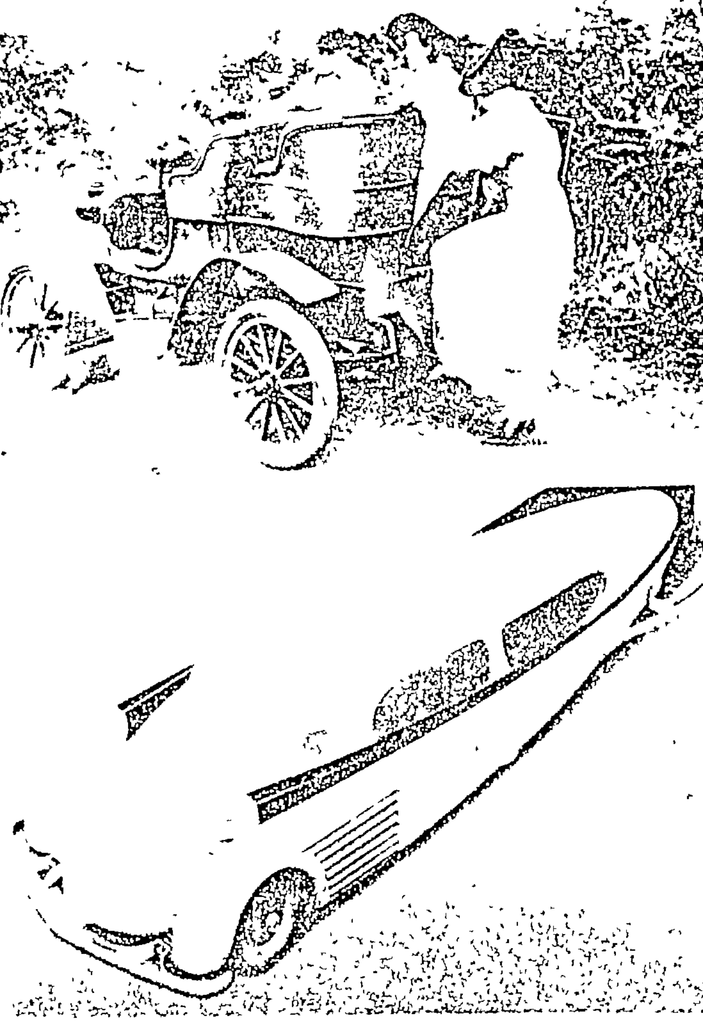
About the most pitiful fate that can befall a human being is to become feeble in mind—to lapse into "second childhood." Who could wish to live to be old, if old age necessarily implied mental senility? The realization that there is no necessary association between the two, and that he who makes a sane bid for length of years bids at the same time for permanent alertness of mind, should prove a new incentive to right living.

A young man may say and believe that he prefers present indulgence to the prospect of long life. He may believe *now* that he does not care to live to be very old. But no sane person with a trace of imagination dare

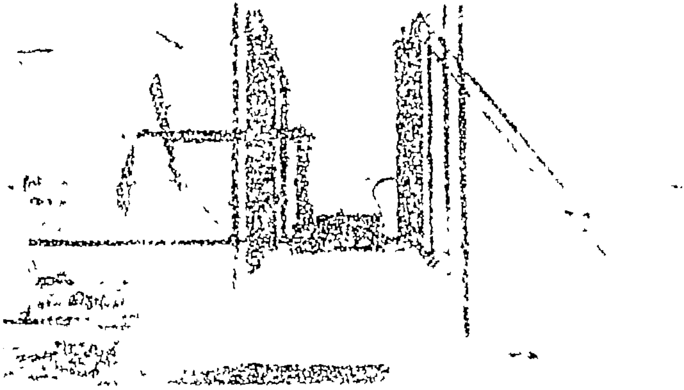
affirm that he could complacently face the prospect of a future term of years when he will be *half* alive—when the mentality that alone made him count as a person is utterly and forever lost.

The way to avoid that danger is to deal fairly, in your early years, with the body that is *You*.

ASSEMBLING AUTOMOBILES



THIRTY YEARS OF AUTOMOBILE DEVELOPMENT



LUIGI CORNARO: PORTRAIT BY TINTORETTO

IX

EATING TO LIVE

THE most successful dietitian who ever lived was a contemporary of Christopher Columbus. I make this appraisal on the assumption that the object of giving heed to one's diet is to insure good health from year to year and long life. The man of whom I speak made so good a selection that he enjoyed superb health and corresponding buoyancy of spirit to the day of his death—which occurred in his ninety-ninth year.

Do not for a moment suppose that this was just a matter of being born with a good constitution. Far from it. Count Luigi Cornaro — the Venetian nobleman to whom I refer—himself records that he had so feeble a constitution to begin with, and had so impaired it by dissipation in his earlier years, that when he was about thirty-five years old his life was despaired of. But he had the "will to live," so he turned about-face, made a hobby of diet and personal hygiene, and soon became a "new man." He continued to be a new man for almost sixty-five years thereafter.

Cornaro tells us himself that at ninety-five he was vigorous of body, alert of mind and savoring what he considered the good things of life far better than he had done in his youth.

"I never knew what beauty was till I was old," he declared. His book might be called a panegyric on the joys of the later decades of life, which only a few men in any generation are wise enough to secure. And he

spoke by the card. For at eighty-three, when he wrote the first part of his book on the art of living, he was able to mount his horse unaided and continued to pursue his favorite pastime of hunting; he often wrote with his own hand eight hours at a stretch, composing not merely the book in question, but treatises on architecture, scientific agriculture and engineering, and wrote a comedy.

Nor was he a mere theorist or dilettante. His palaces at Padua, after his own plans, were notable examples of Renaissance architecture. His engineering plans involved large-scale modifications of the defenses of Venice and the draining of extensive marshes to augment the agricultural resources of the city. On a smaller but still expansive scale, he drained marshes on his own estate at Padua, and by cultivating what had been waste land recouped fortunes endangered by mistakes of his own grandchildren. In a word, his activities were unflagging, and the way he describes them gives evidence of enthusiasm and zest in living that can only be described as boyish, tho he who made the record was a nonagenarian.

The point of all this is that Cornaro did not just "happen" to be alive and active in his ninth decade. He had purchased old age, and paid a definite and tangible price. He believed that anyone might make the same bargain. He wrote his book to tell just what the terms of the bargain must be. He believed that many people might expect a longer term of years than he could purchase, because others had better natural equipment. His own constitution, he declared, was so feeble and had been so much impaired in addition by early dissipations that he could not well hope to live beyond a hundred years People of better constitution, if they would follow his method, might attain, he believed, something like a hundred and twenty years.

The important point, however, is that this man, who seemed doomed before forty, restored himself to health and gained more than sixty additional years of buoyant life by a definite and explicit practise of a formula for long-living.

It is particularly worth recalling that the age in which this centenarian lived was one in which many men were eagerly searching for what was variously termed the Fountain of Youth, the Philosopher's Stone, and the *Elixir Vitæ*—the magic formula or substance, generally believed somewhere to exist, that would give man perennial youth, or at least great length of days, if not actual immortality. Every school-child has been told of the voyage of Ponce de León in quest of the magic fountain. Most readers have heard the name of Paracelsus, who sought the Elixir of Life in the laboratory—and thought he had found it when he learned from the Arabians the trick of distilling alcohol. These were merely outstanding examples among thousands of seekers

Both these men were part-contemporaries of Cornaro. That is to say, there was a period when all three were living. But the lifetimes of the two unsuccessful searchers, added together, barely matched the single lifetime of the one who succeeded. Had Ponce de León turned his boat eastward, through the Mediterranean, instead of toward Florida, and had Paracelsus made a short transalpine journey, they might have had for the asking, from the lips of the erstwhile invalid of Venice and Padua, the secret that eluded them. Then Ponce de León need not have died of a poisoned arrow at fifty-two, nor Paracelsus of an overdose of alcohol at forty-eight.

There is not the slightest probability that either of the seekers whose quests of the elixir of life brought them early deaths would have paid any attention to

Cornaro's life-giving formula had they heard of it. For that formula—and now the secret is out—revealed no magic draft of fountain or abracadabra of ritual. It was a negative formula—and therefore totally devoid of advertising value. What the world wanted—and still wants—is a necromantic philter, to be dispensed at a high price, in a vial; a miracle-working potion, which permits one to transgress every law of health and suffer no untoward consequences.

Cornaro's formula was far from being such a wonder-worker as that It did, indeed, work wonders of physical and mental rejuvenation, and it gave length of years beyond precedent. But it was nothing that could be bought directly for money. It called for no incantations. It was no secret to be revealed in whispers. The whole thing could be revealed in two simple words:

Live temperately!

Yes; that is all. That was the magic formula that transformed a moribund invalid into a vigorous, healthy, joyous personality; and kept the practitioner of the formula alive for nearly thirty years beyond the alotted three score and ten. An absurdly simple formula, surely. But an explicit formula, as we shall see in a moment. And a formula that cannot possibly be laughed off, because it worked so amazingly

At the outset, let it be clearly understood that, tho he deals largely with the matter of diet, this long-liver was no food faddist. He never made the mistake of assuming that the diet he had found so admirably suited to his own needs would meet the needs of everybody else. On the contrary, he explicitly states that everyone must find out for himself just what foods are best for him, individually. "No man can be a perfect physician except for himself," was one of his maxims. His phrase

is perhaps the forerunner of the familiar: After forty a man is a fool or his own physician—a half-truth worth considering when diet is in question.

Cornaro tested his own needs with scientific—or perhaps we should say psychological — precision. He first made the tentative assumption that foods a person likes are the ones his system requires But he soon found this idea fallacious. He liked salads and fish and pastries and fruit and wine, and he could take none of them without unpleasant results. He finally settled on a ration which served so well that in a few months he became a "new man," free from ills of any kind. Soon he came to regard himself as immune to every type of malady—and his record of sixty-odd years of abounding health seems to justify the appraisal.

The ration that served so well was exceedingly simple. It consisted of bread, bread soup, eggs and meat (usually veal, lamb or kid) Later in life, a certain amount of fish. Apparently no vegetables or fruits.

At first glance, that seems not merely a meager, but a doubtfully adequate, food supply. Analysis shows, however, that it meets nearly all theoretical requirements. We may assume that the bread was made from whole-grain flour. So it supplied mineral salts and vitamin B. Eggs supplied vitamins A, D, and E and G. Meat supplied iron and phosphorus. Only vitamin C is unrepresented; and as to that, I shall say something more in a moment.

Theories aside, this diet did suffice to keep one man alive and in health almost to the century mark. For him it was a good diet. But did it really have the share he ascribed to it in prolonging his life? And if it did, why has not a similar diet made thousands of other centenarians? A natural question, certainly: for millions of

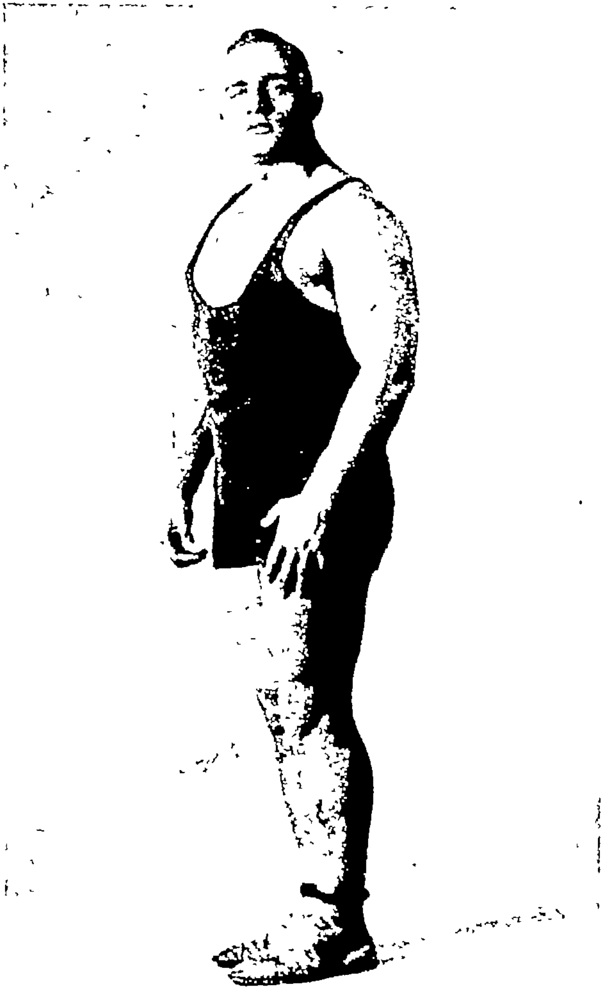
He regarded this as an individual peculiarity, and did not think of condemning wine as a beverage for people in general. To the end he regarded his "new wine" as the "milk of old age." But his own words, as just interpreted, make it clear that this appraisal has nothing to do with alcohol. Needless to say, he makes no reference to alcohol, as such, for this "essence" was at that time hardly known outside the laboratories of the alchemists.

A moment ago I suggested that the "new wine" of Cornaro probably supplied a small amount of energy food, in the form of grape sugar. This can hardly have added more than 250 calories or so at best. So the total fuel supply was lower than what is commonly considered normal. The result proved that it was adequate. But it certainly left no residue to be stored as fat. The extant portrait of Cornaro, by Tintoretto, shows him as very thin. But that testimonial was not needed. He could not have been otherwise on his diet of twelve ounces of solid food and fourteen ounces of grape juice.

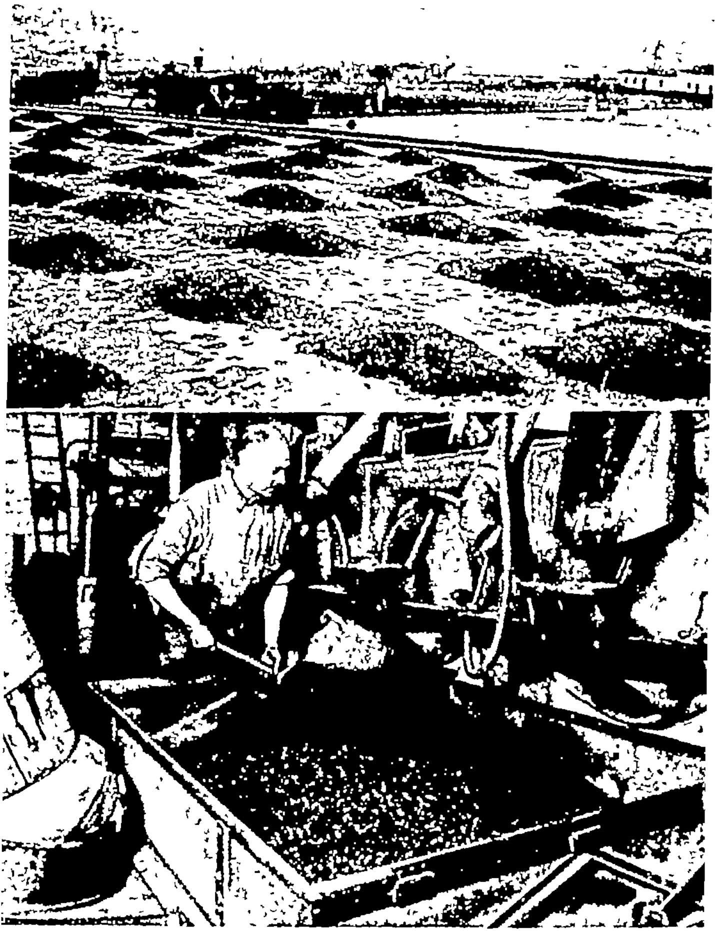
In the final analysis, then, it appears that the really essential particularity of Cornaro's diet was its sparseness. He had to have proteins and carbohydrates and fats, of course; also, mineral salts and vitamins. But many foods other than the ones he used might have met these requirements. For example, milk instead of meat; vegetables instead of bread, and so on. Any ordinary table supplies all the essentials.

But the desideratum is, not what is taken—but what is not taken. Cornaro himself quotes an old maxim or two worth repeating: "Whoso would eat much must eat little." "The food we eat does not do us so much good as that which we do not eat."

These are age-old maxims, but the man who heeds them is one man in ten thousand.



ZBYSZKO. WRESTLING CHAMPION AT FIFTY



DRYING AND ROASTING COFFEE

X

DRUGS THAT ENTICE

WHAT about alcohol? What about tobacco? What about tea and coffee? Few questions are oftener asked of a physician by his patients Few are more difficult to answer categorically And few things are more certain than that the patient will give very little heed to the answers, whatever their import. Or perhaps that is not quite the way to state the case. The patient will listen eagerly, and for the moment intend to follow whatever advice is given him But if admonition runs counter to his habits of long establishment, he will have no option but to make obeisance to habit and shelve the new inclination

It is not worth while, therefore, to waste much space on admonitions as to the use of the famed solacers of appetite, individually or collectively. Everybody knows that their use is not conducive to added health. Everybody knows that athletes in training are not permitted to smoke, are rarely permitted to touch alcohol in any form, and are usually advised to give up tea and coffee as well. In a word, everybody knows that the consensus among practical students of the problem of helping the body-machine to function at and above par is that artificial stimulants do not help, quite the contrary.

No one disputes the injurious effects of alcohol in excess. No one doubts that it is easy to exceed the harmless minimum, if such minimum there be. No one who has long used tobacco doubts that at times its effects are

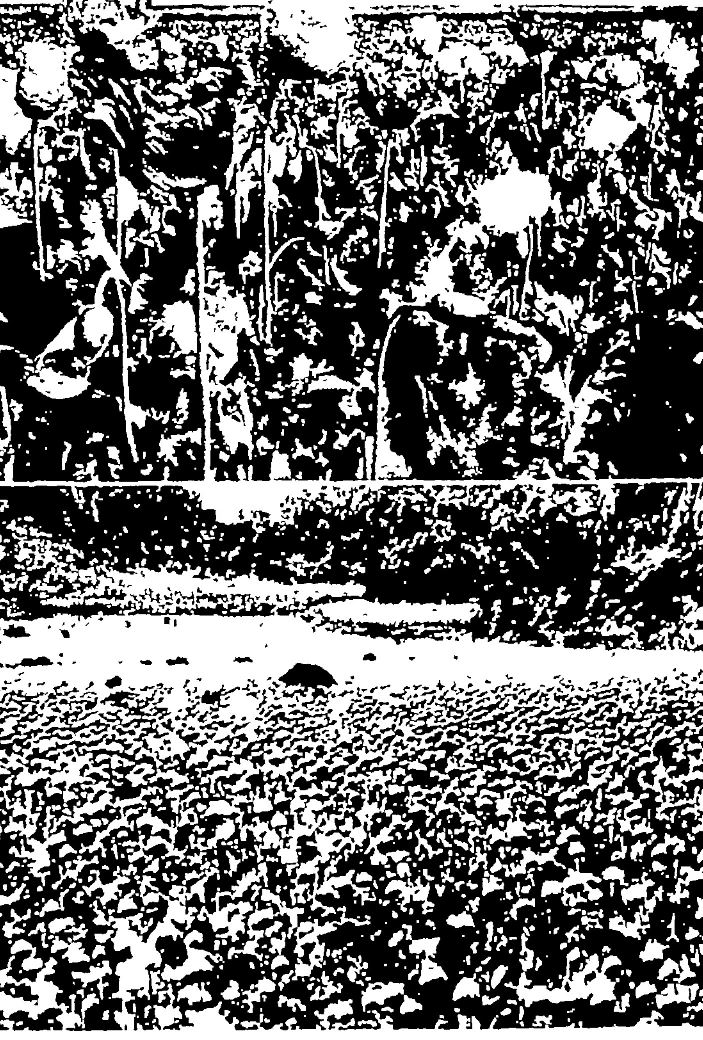
other than beneficial. There are few habitual smokers who have not at one time or another—and usually many times—"sworn off," or at least resolved to cut down on the number of cigars or cigarets for a period. There are thousands of smokers who have learned that they must choose between tobacco and alarming symptoms of heart disturbance.

But what of all that? What of statistics of life insurance companies, which show that users of alcohol are not as good risks as abstainers? What of medical testimony to the share of alcohol in the causation of maladies of liver, kidneys, arteries, heart? What, in short, of the aggregate experience of mankind as to the relation between alcohol and tobacco, on the one hand, and health of the human organism, on the other? What bearing have these things, individually or collectively, on the problem of longevity, as applied to the average individual human being?

The answer is simple: They have no bearing whatsoever. The average individual will continue to take alcohol and to use tobacco and the other solacers; or he will avoid one or the other or all of them, regardless of advice, admonition or evidence, just as he always has done. So why waste words over the matter?

It is true that I have in the past wasted a good many words on the subject. Once I even wrote a book about it. Here, however, I shall not even summarize the evidence. I shall merely make a brief statement of personal experience.

In 1884, when I graduated in medicine, the alcohol problem was just as much bruited and mooted as it is today. My own attitude toward the subject was one of critical neutrality. If alcohol would help my heart to keep on running, I intended to use it. If not, I should



THE OPIUM POPPY IN TURKEY

give it a wide berth. The evidence before me was inconclusive, and my two chief authorities were divided. My father had used alcohol in his practise, and believed he had saved the lives of many patients (notably diphtheria cases) with it. He had taken whisky in extreme moderation, as a regular medicament to stimulate his heart, for several years before his death.

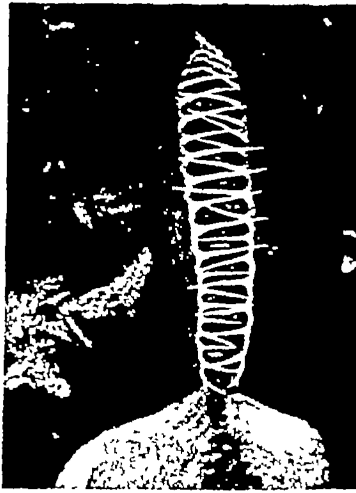
Meantime the most famous physician I had known, Dr. Nathan S Davis, dean of the faculty at Northwestern University Medical School, where I took my degree, was a notable opponent of the use of alcohol in any form. He declared emphatically that alcohol had no place in medicine

How was a novice to decide when his two main authorities so radically disagreed? The answer I found was: Investigate for yourself At the outset, I recalled that alcohol had not kept my father alive, but had permitted his heart to stop beating suddenly when he was only fifty-seven; whereas Dr. Davis, when I knew him, was robust at seventy-odd (he lived to be eighty-seven) This, of course, proved nothing; but it was at least suggestive. Personal tests proved negative. But in the ensuing ten years I had opportunity to make observations that ultimately seemed convincing. I was successively a general practitioner in an Iowa town, assistant physician and pathologist in three large hospitals for the insane, medical superintendent of one of the largest general hospitals in the world, and a psychiatrist in private practise in New York City.

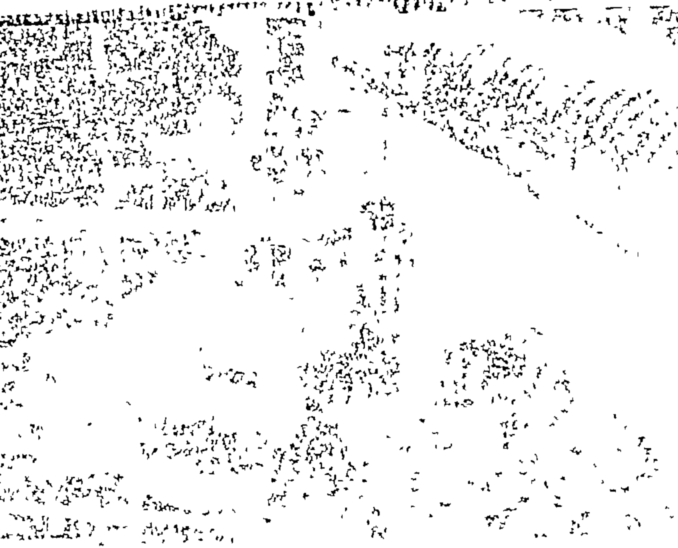
After I had treated a few hundred, and professionally observed several thousand, cases of alcoholism, ranging from delirium tremens to chronic and incurable alcoholic dementia, and had personally performed a few score autopsies that revealed atrophied brains or cirrhotic

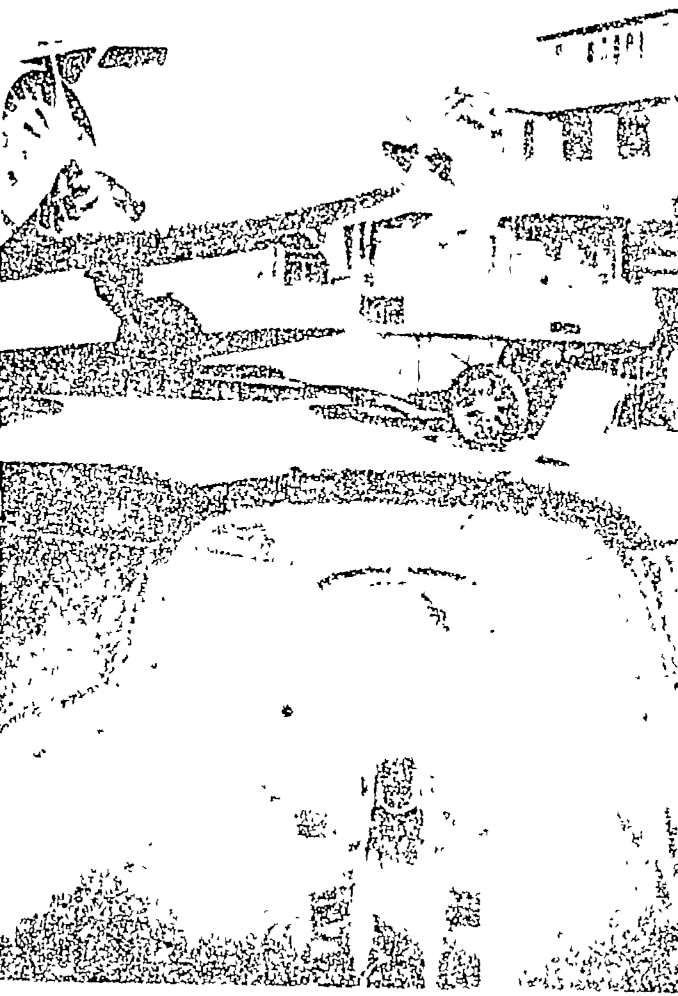
livers or degenerated kidneys ascribable to alcohol, I was able clearly to decide that I, personally, could get along without alcoholic beverages. Subsequent investigations of another type served only to sustain the conviction that alcohol is not an essential medicament in any quantity, and that it is an insidious and deadly poison when used habitually in moderate quantity. No one needs to be told what it is when used in excess.

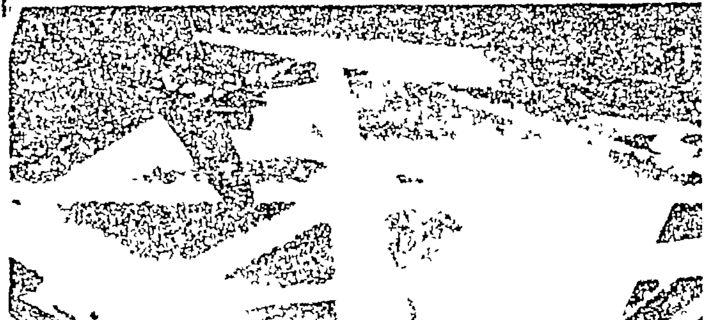
Whether or not the pleasure to be derived from the use of alcoholic beverages outweighs the danger is a matter for individual decision. If you find life worth living, and would like to make a bid for as much of it as possible, you will do well to think twice before you allow yourself to become a votary of the alcohol habit Drug habits of any kind are exceedingly hard to break



VENUS FLY-TRAP: A PLANT THAT EATS INSECTS







PHOTOGRAPH BY ARTHUR ACHERT, AUTO-
GRAPHED THE DAY BEFORE *THE* FLIGHT

GEORGE BOTHNER. DOUBLE NELSON
CROTCH HOLD AND HAMMERLOCK

XI

EXERCISE AND HEALTH

FOOD and exercise are correlatives. You obviously cannot exercise without help of the energy supplied by food And every movement you make calls for more food to meet the energy exhaustion involved. By merely raising your arm during a test for basal metabolism, you increase the oxygen consumption measurably. And, of course, every more strenuous movement multiplies the effect. The sole function of food, in the last analysis, is found to be the supplying of energy for physical movements, on one hand, and the atomic movements we term chemical activities, on the other, and these two forms of movement are indissolubly associated.

In selecting foods, we endeavor to supply the body-laboratory with chemicals for favorable reactions In performing voluntary exercise we do nothing more at first hand than to cause muscles to contract; but the ulterior effect is to facilitate circulation of the blood, and promote an indefinite series of chemical reactions involving, first and last, every tissue of the body

It is rather startling to reflect that, of all the myriad activities of the body, only a single type of action is under voluntary control. Much as we pride ourselves on being creatures of intelligence—"thinking" animals — our activities, physical and chemical, are in the main purely instinctive and entirely beyond conscious control by our vaunted "minds." The only thing in the wide world we can do to prove that we *have* consciousness or

minds is to cause the contraction of a muscle or group of muscles. And this capacity is shared by practically every member of the animal kingdom; so we should not greatly plume ourselves on that achievement.

Our present concern, however, is not with such philosophical whimsicalities as these, but with the practical results of voluntary physical movement in their bearing on the chemical activities of the body which, in accordance as they are performed well or ill, give us health and invite happiness or condemn us to illness and suffering. In particular we have to make inquiry as to the kind and degree of exercise best calculated to promote bodily welfare.

Let me say at the outset that all my life I have been an enthusiastic advocate of the health-giving value of exercise and a zealous practitioner of what I have preached. If I praised boxing and wrestling, it was because I had personal experience of their benefits; and I still praise them because, at a time when I am far beyond the competitive period, I still feel the aftermath of middle-life athletic practises that gave a tone and an elasticity to my muscles, that they have by no means altogether lost, and contributed to a buoyancy of mind, zest in the pursuit of every task and capacity for intensive application that are unabated.

I speak in particular of competitive sports, because I believe that the full benefits of exercise are to be attained only when the mental elements involved in competition supplement the mere muscular movements that set the heart beating more vigorously and the blood pulsing. Merely to raise dumbbells or work pulley machines is better than not to exercise vigorously at all, but only one stage better. Moreover, most of us lack the kind of pertinacity that will keep us at such ungrateful tasks

CORBETT — FITZSIMMONS

DEMPSEY - - TUNNEY

long enough or persistently enough to gain even the purely physical benefits of exercise.

On the other hand, it is not to be denied that physical contrivances have their place; notably because they can be used at any time and anywhere, without breaking significantly on the day's work. I have always made it a practise to keep a pair of fifteen-pound dumbbells on my desk, to be swung now and then for two or three minutes at a time, if only to neutralize the inertia of long sitting. Much more generally, however, I have practised a system of what might be called "self-competition," which I devised (and published) while I was still a young man.

The method—which I commend to the attention of all desk workers—consists in opposing one set of muscles to another, by clasping the hands together, either before or behind the body, and thrusting them in every possible direction, constantly resisting every movement or attempted movement of one hand with an attempted counter-movement of the other By clasping the hands behind the head, the muscles of neck and torso are brought into the scheme of action; and, with a little ingenuity in posturing, you will find it possible to involve the abdominal muscles, which perhaps most of all are in need of your attention.

Notwithstanding what I said about competition, there have been periods of my life when office work claimed my attention too imperiously to permit time for planned recreation, and I have kept myself in fair physical trim chiefly by the procedures just outlined, even when for months together I indulged in no more tangible exercise —not even walking, on the average, so much as a quarter of a mile in a day. And I still use the method frequently, when I have no opportunity for out-of-door

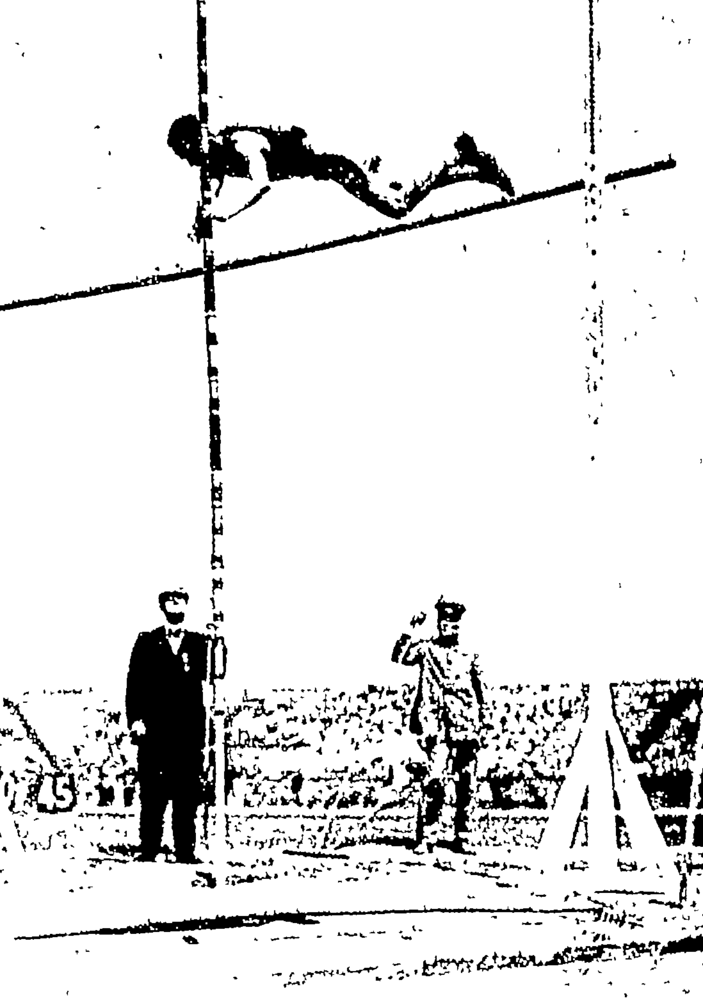
work with spade or ax—as, for example, when touring in an automobile; even, with modifications, while holding the steering wheel.

Such mild exercise as this, calling for very few calories of energy, would naturally fail to meet the requirements of health unless you restrict the amount of fuel food eaten. This very important relation between food and exercise, to which reference has previously been made, may advantageously be stressed, for it is often overlooked The question of how much exercise you need cannot be answered without consideration of the question of how much food you eat

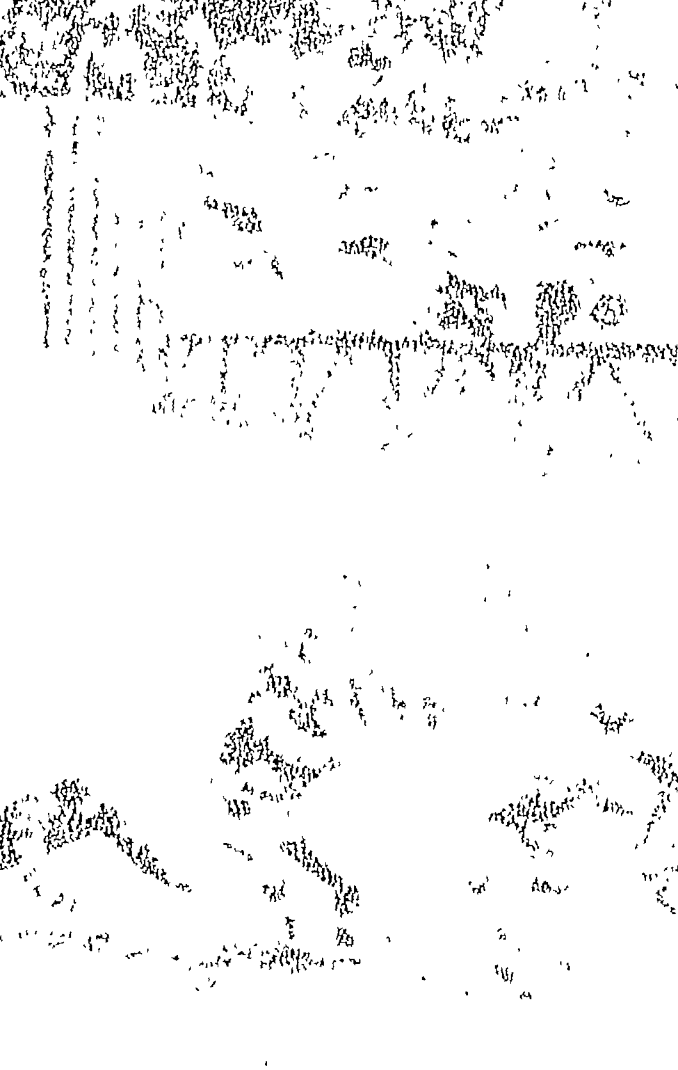
If you live abstemiously, supplying your body not much fuel beyond the basic minimum requirement, you need exercise only enough to keep the muscles in tone. But if you habitually eat a good deal more than enough food to meet the basic requirement, you must take correspondingly more exercise in order to keep in similar condition. That may seem an almost axiomatic statement of fact, but in reality it is a truth seldom realized or acted on. People are forever prating about needing more exercise, and not being able to find time for it, when what they really need is less food They are quite sincerely unaware that they could balance their health ledger as effectively by eating less as by exercising more.

The person who habitually overeats, and takes up some violent form of exercise to keep himself in health, is acting rationally, perhaps, but he is not adopting the simplest procedure He could save time and money, and usually get better results, by merely cutting down his food budget

At least that is true so far as the mere physical effects are concerned There is, however, another element in most exercises, and in all competitive games, which must



POLE VAULT



BASKET-BALL AND SKATING

on no account be overlooked. This is the mental element. By and large, that is the more important part of the project. Many players of games gain weight instead of losing it, and are no better off physically after a long term of exercising than at its beginning. But to complete the story it should be added that the exerciser may none the less have been greatly benefited by his experience. To match strength, skill and endurance against a competitor implies exercising the brain no less than the muscles. And it is likely that the brain needed the exercise more than the muscles needed it

Viewed in this light, exercise takes on new importance, and it no longer seems a matter of indifference as to what form of exercise is taken. Your individual temperament and tastes must be considered.

If, for instance, you are a lover of Nature, you could ask no better exercise than you may gain by wandering over the hills and through the woods. Trees, flowers, wildlings of many kinds delight your eye and arouse a never-ending sequence of pleasurable emotions. A chance glimpse of a rare warbler in a treetop—a thumb-sized fairy called Parula, for example—may make this, for you, a red-letter day, to be forever memorable. The physical exercise of walking has added a modest increment to your store of health; but the emotional experience has veritably broadened and lengthened your life.

Yet another person, of different tastes, having precisely the same outward experience, would have been simply bored. The benefit to his body would have been negligible, and the effect on his mind worse than negligible. For him, the only walk that could bring benefits comparable to yours would be a tour of the links, oblivious of everything but a small white ball, and with no desire on earth but to break under ninety.

For this enthusiast, golf is a splendid game—fine exercise and supreme mental enchantment. Yet here is a third individual for whom golf would represent excruciating punishment. To get pleasure out of exercise, this person must have a racket in his hand, or perhaps a fish-pole or a paddle or a gun. Or he may yearn to feel his hands encased in boxing gloves, or to come to grips barehanded with an opponent on the wrestling mat. He may even get more pleasure out of hoisting dumbbells and swinging Indian clubs than he could gain from any outdoor recreation or two-sided game whatsoever.

Every man to his taste. And the present point is that only by selecting some form of exercise or game that does suit your taste can you hope to derive full benefit from muscular exertion. Exercise that is only another form of work is of doubtful value to your body and worse than valueless for your mind.

You must not forget, however, that a game which at first seems boresome may become fascinating when you have attained a certain measure of skill in its pursuit. My own maxim has always been to make personal trial of every game before pronouncing a verdict on it. My personal taste runs to strenuous exercise, with a competent opponent in front of you to counter every move and keep your wits ever on the alert. But having said that, I restrain the impulse to indite a panegyric on the ideal exercise. I content myself with repeating, "Every man to his taste," and with presentation of a general formula that plays no favorites.

The ideal exercise for you is anything that commands your interest, carried to a point that stimulates the circulation and brings the perspiration, but not to the point of fatigue from which you do not quickly recover. That is the formula.

Here I am speaking to the normal individual It goes without saying that anyone who has reason to question the condition of his heart or glandular system should not undertake violent exercise, competitive or otherwise, without advice from his physician. It may be added, however, that heart specialists nowadays are likely to be firm advocates of exercise, and often prescribe even competitive sports of less strenuous type for patients having organic lesions that would once have been supposed to make vigorous activities of any kind tabu.

One other word With exercise, as with the taking of food and with most other human activities, the premium is on the happy mean. If crippled hearts may sometimes be mended by proper exercise, sound hearts may be crippled by prolonged overexertion. In your games, as in all other activities, remember the cogency of the old Greek saying: "Nothing too much!" The early demise of numberless noted athletes has proved that hypertrophied hearts do not conduce to longevity.

POLO

HIGH DIVING

XII

LIFE-GIVING HOBBIES

ARE the "improbable" years beyond three score and ten worth buying? We may fairly assume that they will not be attained, except at the cost of good measure of physical discipline and mental spurring that may not always be agreeable at the moment—running counter, in fact, to "natural" impulses that often seem imperative. Is the game worth the candle? Might it not be better to say with Byron, "I will live my life to the full, and then, good night" — accepting the Byronic estimate of full living as unbridled license of all the senses?

Well, the question is at least worth considering. And, viewing the matter solely from the egoistic standpoint for the moment, the answer depends, I think, on what you are inclined to do with the added years if you earn them. How do you purpose to spend the eighth and ninth decades of your life, if you should indeed live out your normal span?

An absurd question, you say? You will cross that bridge when you come to it? You are much too busy thinking about the affairs of today to concern yourself about a remote, and even improbable, tomorrow?

Such a response is natural enough. But it is not the right answer. If you are to have those years at all, you must begin to purchase them while you are young, and if you are to find them worth having, you must begin now to prepare yourself to enjoy them And in strictly

practical terms, the best preparation you can make is to provide yourself fairly early in life with a HOBBY that has inexhaustible possibilities

But what, then, *is* a hobby?

A fair question, and easily answered. A hobby is any kind of purposeful activity whatsoever that involves definite and intelligent effort *of a different kind from the effort involved in the work by which you earn a living.* The point involved is the difference between *work* and *play*. Work, almost by definition, is the performance of a task for purposes of monetary gain. Play is the performance of a task for the fun of it. The pursuit of your hobby must be a play-task, not a work-task. It may involve greater physical or mental effort, or both, than your work-task involves. But the connotations of the two are absolutely different. One task you pursue because you must, or at least because you ought; the other task you pursue because you voluntarily elect to do so.

It does not follow that you may not enjoy your work. It may absorb and fascinate you. But if, year in and year out, you find your work *the* particular kind of activity of all others you would prefer—then your work-task has become in effect a play-task, and you are one of the fortunate few for whom vocation becomes a hobby, or whose hobby has become a vocation.

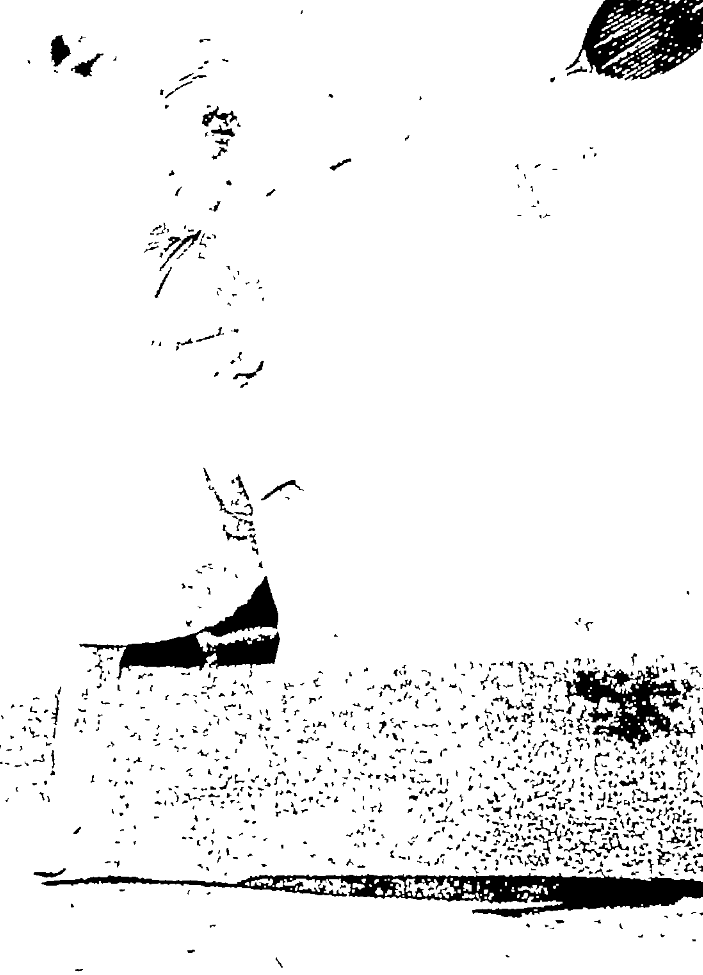
The successful painter, of all others, is perhaps the man whose vocation comes nearest this ideal. And yet, if you ask him, you will probably find that the union of work and play, even in his case, is not as ideal as it may seem. Very commonly you will find that he is not doing the *kind* of painting he would like to do. He prefers landscape painting, perhaps, but can sell only portraits. So he *works* at portrait painting and *plays,* when he can, at landscapes.

The ultimate truth is simply that any task which we *must* follow habitually becomes work, however eagerly we played at it in the beginning. So the rule that every-one should have a hobby has universal application. Should your hobby in course of time become lucrative, and thus take on the aspect of a work-task, you must seek another hobby. And in any event it is not unlikely that you will find it expedient to seek a new hobby from time to time. The very pursuit of the hobby may develop new tastes or capacities that will invite other hobbies But if the pursuit of the hobby, as such, has been successful, by middle life you are likely to have found a play-task of such significance that you will have no inclination to abandon it.

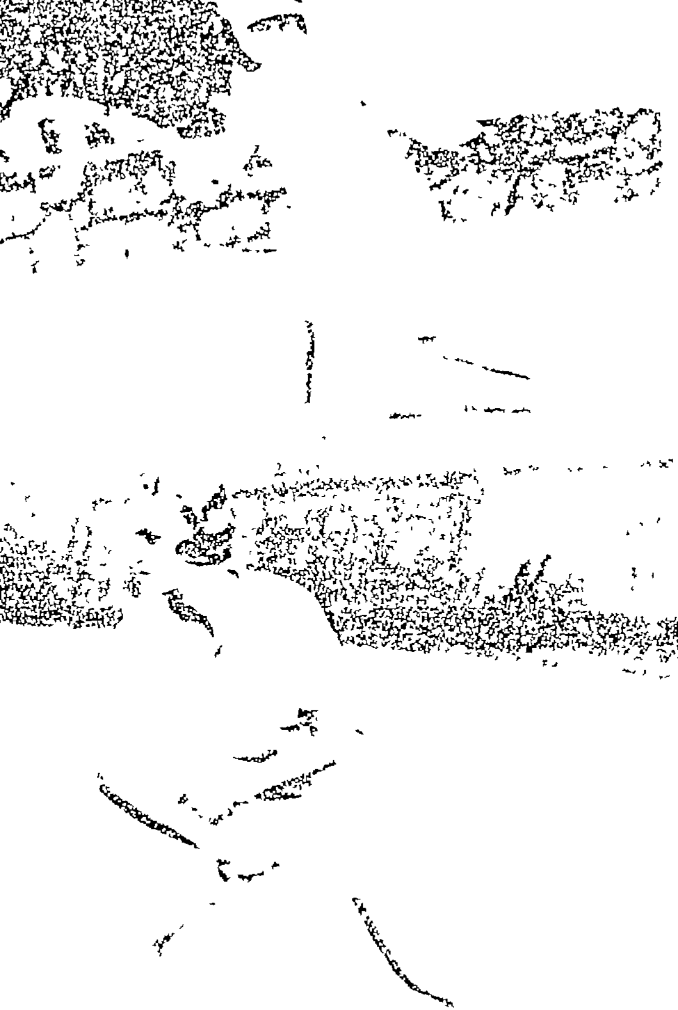
Your play-task, of course, may become a serious pursuit. It may be precisely like the work-task of your neighbor. But because you have voluntarily chosen it, and pursue it with ever-growing zest—with no thought of monetary profit—it remains a hobby for you and gives you the benefits that a hobby alone can give

One of these benefits is measured in terms of zest-of-living in the present; another, in terms of potential zest-of-living in the remoter future—that is to say, during the term of those "improbable" years, should you attain them. It may or may not be expedient for you to give up your work-task when you come to those years. But most certainly you will not give up the play-task, if the years are to prove worth the winning It is proverbial that the successful business man who has never learned to play becomes a pathetic figure when he attempts to retire from business. Unless he can late in life acquire a hobby that grips him, life becomes a bore, and he may well conclude that the "improbable" years were not worth buying. More than that, his life will become so

TILDEN SERVES A CANNON BALL



MLLE LENGLEN IN ACTION



zestless that he will probably lack the will to live which (even tho only subconsciously exercised) is prerequisite to long-living.

In this view, then, the hobby is not only a pleasure giver but a life lengthener. In proportion as it is zealously cultivated, it has influence to make the "improbable" years attainable, and to make them worth attaining. So we reach the paradoxical conclusion that hobby-riding may become, in the long view, the most important business of life—the avocation, in the ultimate appraisal, taking precedence over the vocation.

In speaking thus, I have chiefly in mind the value of the hobby to the individual who rides it. But it may chance on occasion that hobby-riding leads to farther goals. Herschel the bandmaster chose astronomy for a hobby, and through telescopes made with his own hands discovered hidden secrets of the heavens and gave the world a new conception of the universe. The preacher Priestley made chemistry a hobby, and became the discoverer of the life-giving gas, oxygen. Seymour Haden, London physician, took up etching, and—in the midst of unremitting professional duties—became the foremost authority on the art of etching and one of its most famed practitioners of the nineteenth century. Pierpont Morgan, foremost banker of his generation, made book collecting his hobby, and enriched the world of culture in measure far beyond his contribution to the stabilization of the financial world.

These illustrations are typical. And if one were to make an extended catalog of important achievements attained through hobby-riding, it might lead to the paradoxical suggestion that, by and large, men's avocations are more significant than their vocations, and that the chief progress of civilization has been effected as a by-

product of the zealous pursuit of hobbies. Without asking you to go quite so far as that, let me cite, at random, a few illustrations of significant things that have been done by men of many minds in fields that they entered as amateurs.

Take the case of the Wright brothers. They were bicycle dealers, but they amused themselves in off-business hours with the crazy project of making a machine that could fly. The thing was impossible, as thousands of futile experiments had shown. But these young men pursued their bizarre hobby, to the amusement of their neighbors, with absurd zeal, after the manner of hobby-riders in general. You know the rest.

Go back a little, and consider the painter, Morse. He was a well-trained portrait painter, and achieved distinction enough to be chosen president of the National Academy of Art. But have you ever seen any of his pictures, or heard them praised? Hardly. You have heard, tho, about the electric telegraph. And that was a toy that he invented, because he liked to fool with electricity when the light was not right for painting.

Then there was a barber named Arkwright. At odd times when there were no customers to shave, he played with the idea of a whirligig thing that might be made to twist fibers of cotton or wool into thread. He had seen women do that at their spinning wheels, of course. But he wanted to see if a machine couldn't be made to do it a good deal faster. A grotesque thing for a barber to be dreaming about, when any trained machinist could tell you that machines can't take the place of human brains and fingers. All the same, this barber rode his hobby. And you perhaps have seen pictures of a modern mill, where one girl tends a whole battery of perfected Arkwright spinning jennies that in one hour produce

as much thread as the best old-time wheel-spinner could produce in a lifetime.

Then there was a hobby-rider of a quite different type, named Schliemann. His business was selling indigo, which he imported from China. His hobby was the study of languages. Among others, Greek. That led him to read Homer and to become enthusiastic over the idea of searching for the ruins of ancient Troy. The scholars were not very sure that Troy ever existed at all, except in myth and hero tale. But the hobby-rider knew better. And now all the world knows that he was right. And for all the future no one can think of Homer and the greatest of epic poems without thinking also of the indigo merchant Schliemann—tho few recall and nobody cares that he *was* an indigo merchant or anything else but a zealous and miraculously successful hobby-rider: a dreamer of fantastic dreams that came true.

Still another type. This time an emperor, ruler of the vast dominions of Rome, at its greatest glory of the Byzantine period—Justinian the Great. Absolute arbiter of millions of lives; conqueror of armed legions from Persia to Italy; unchallenged ruler of one of the mightiest of temporal empires, and a hardly less potent shaper of spiritual destinies of a world half pagan and half Christian. A builder of palaces and temples, raising Constantinople to its pinnacle of glory as the world metropolis; a potentate who held the civilized world in thrall to the day of his death, at eighty-three—after a reign unequaled in duration by that of any emperor before or after, and at an age which almost no other Roman attained during a period of more than a thousand years.

But all that official pomp and glory is only a name and a memory. Nothing came of it, and the world would

have been neither better nor worse because one of the long list of emperors had been Justinian, had not that particular wearer of the purple had a hobby that he never ceased to ride from the beginning to the end of his reign. He, who could make laws with a wave of his scepter, had a passion for the study of ancient laws. And the codifications of these laws, made at his mandate, survive as the *Institutes* and *Pandects* and so on of Justinian, which lawyers constantly consult even to this day.

Thus the *Code Justinian* preserves a name that otherwise would be all but forgotten. Just as perhaps, in a not so very remote future, the *Code Napoléon*, representing the hobby of another emperor, may keep time from altogether dimming a name that loomed large in its generation but left few other permanent records of its importance.

Incidentally it is pertinent to note that Justinian, who so far surpassed in length of years all other wearers of the Roman purple, might be cited as a votary and exemplar of the thesis that abstemious living and strenuous mental application in many fields of work, along with zealous hobby-riding, are the passports to health and long life. Living in a world of unexampled wealth and luxury, in a palace with a local entourage of upward of three thousand retainers and servants, his personal habits, as summarized by Gibbon, were these:

"His repasts were short and frugal: on solemn fasts, he contented himself with water and vegetables; and such was his strength, as well as fervor, that he frequently passed two days and as many nights without tasting any food. The measure of his sleep was not less rigorous; after the repose of a single hour, the body was awakened by the soul, and, to the astonishment of his

chamberlains, Justinian walked or studied till the morning light. Such restless application prolonged his time for the acquisition of knowledge and the despatch of business . . The emperor professed himself a musician and architect, a poet and philosopher, a lawyer and theologian; and, if he failed in the enterprise of reconciling the Christian sects, the review of the Roman jurisprudence is a noble monument of his spirit and industry."

Elsewhere Gibbon sugggests that Justinian's rescue from the plague, which devastated the empire, taking sometimes ten thousand lives a day in Constantinople alone, and tens of millions in the aggregate, may have been due to his abstemious living, even as Socrates had been saved by his temperance, in the plague of Athens.

Mention of the chamberlains of Justinian, in Gibbon's appraisal, reminds one that the chief of these, for many years, was a little eunuch named Narses, who has the distinction of surpassing all contemporaries, and all known Romans of any period, in length of years He lived to be ninety-eight. A few other professional ascetics earned length of years. But in general notables of the Roman principality, republic or empire, were relatively short-lived. Justinian and his chamberlain Narses were the only two Roman civilians whose names appear in a list of one hundred distinguished men of all times and nations who lived beyond eighty.

It seems not unreasonable to suppose that a chamberlain who was likely to be called from his bed to attend his royal master at all hours, and who had at all times before him so remarkable an example of the value of abstemious living, hard work and vigorous thinking, may have acquired something of the habits he witnessed. Indeed, one can hardly suppose that his tenure of office

would have endured had he not done so. Does that, perhaps, explain in some measure the long life of the eunuch? I like to think so, and the word pictures of the scrawny appearance of the eunuch, no less than the records of his later history, confirm the suggestion.

It is not for that reason, however, that I dwell on the case of the chamberlain in this connection. It is because the case of Narses seems to me the supreme example in all history of spectacular hobby-riding. Recall that this man was a eunuch: a despised nondescript, fitted only for menial service For more than an average life-time he was a servant in the palace, and one might suppose that he had reached the pinnacle of his possible career when he became head servant But as the chief of menials directed the machinery of the royal household, he apparently dreamed of affairs in a very different world. As he directed the activities of a staff of servants, he dreamed of himself as directing companies of warriors instead In leisure moments he pored over maps, followed in imagination the fortunes of Belisarius and other generals of Justinian's armies in distant fields; imbued his mind with military lore.

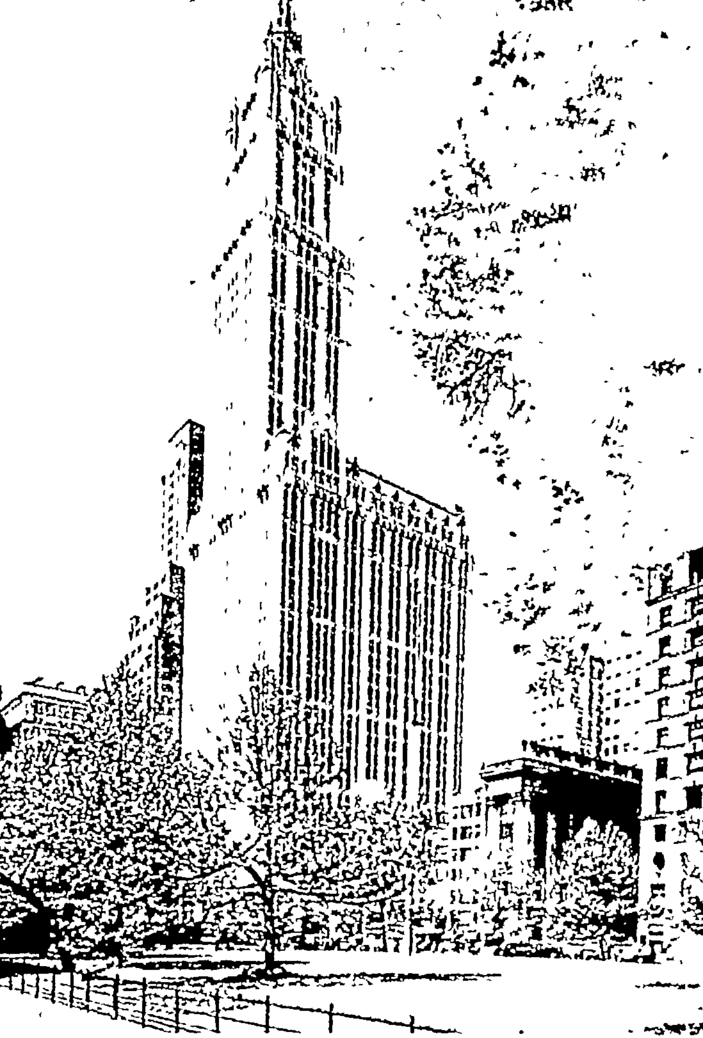
In a word, tho his physical activities were confined to the walls of a palace, he rode his hobby of the study of military affairs far afield. He visioned dreams that would be presumptuous for any man, and which were grotesque for a servile eunuch.

But note the sequel. Every historian knows it. The mighty Belisarius recalled, in disgrace. The despised eunuch far afield, not in dreamland, but in Italy, at the head of victorious armies; making an immortal name for himself, as one of the great generals of all time. Then Narses the Prefect of Italy—vicegerent, with powers little short of those of a wearer of the purple. Narses

the menial eunuch become Narses master of armies and the ruler of a principality. History is said to repeat itself; but it gives us no other true tale quite like that.

And, by the same token, to bring forward any other examples of effective hobby-riding would be an anticlimax. Let the examples given suffice to suggest that your choice of a hobby must depend on your own inclinations, propensities, capacities and adaptability. Probably the final choice will be determined by the old process of trial and error But for that very reason, among others, you should start choosing early in life. Better late than never, tho. The essential thing is that you have no option but to choose *some* hobby, if you are to make bid for worth-whileness of living in the present, for longevity, and for the zestful savoring of the potential resources of the erstwhile "improbable" years that for you become a reality.

The range of choice is wider in our day than ever before Modern science has pushed the barriers of the unknown back farther and farther, exposing wider and wider fields for exploration. Every practical invention suggests new inventions that are needed. We are only at the beginning of progress



THE BEAUTIFUL WOOLWORTH TOWER

THE RECENTLY EXTINCT HEATH HEN

XIII

MUST ALL RACES DIE?

CAN any race of animals survive indefinitely? That is a question which comes inevitably to mind, as one follows the story of animal life of past and present. It is a question that no one can answer categorically, or with pretense of finality. But perhaps our studies of evolutionary history supply some data that have bearing on the problem. At least they stimulate us to make inquiry as to *why* so many animal races of the past have vanished. After that, we may or may not feel justified in hazarding a guess as to whether the implications favor or tend to repudiate the assumption that extinction is the ultimate goal of every evolutionary experiment.

First, then, a brief résumé of the historic facts. Of *living* species (including fairly valid subspecies) of mammals, there appear to be about twenty thousand. The *extinct* species (of corresponding taxonomic value), could we enumerate them, would run into unguessable millions. If all the direct ancestors of any living species could be examined, at intervals of, say, a million generations, each genetic group would rank in the eye of the classifier as an independent species; and such an estimate, according to accepted standards, would no doubt be justified. Under stress of ever-changing environments, Evolution has always implied *change*.

But such an appraisal as that hardly brings us within sight of our problem. A species that becomes extinct, yet leaves descendants in perpetuity, dies only in name.

Its blood (or more literally, its germ-plasm) persists. Its descendants have merely kept up with the times, changing to meet new conditions. They have thereby shown the vitality of the stock, not its vulnerability. There is nothing in such an observation to suggest racial mortality, but quite the opposite.

Accepting that view, and reflecting that every living creature has of necessity behind it an unbroken line of ancestry, back to the very "beginning" of animate life —we seem suddenly and unexpectedly to have come close to the answer of the question with which we started. At least it is evident that, up to the present, extinction has *not* been inevitable for the strains of mammalian life now represented by upward of twenty thousand species.

If, then, it is proved that racial strains can persist for, say, seven or eight hundred million years, what can be the utility of argument as to their future persistence? *Obviously none. We may take it as established that*— short of some world cataclysm that renders life impossible on the globe—mammalian creatures, however modified, may be expected to continue to exist on our planet for tens of millions of years to come. No other inference seems valid.

That conclusion, however, leaves untouched the question as to what manner of creature the mammal of the future may be expected to become. The real point of interest concerns the *kind* of mammal that is likely to persist.

To bring the matter home, the precise question of interest concerns the probable persistence of the particular mammal called Man. And the only evidence that can be supposed to bear on that question is not to be based on observation of past races that survive in their

direct descendants, but rather on examination of those other races—*which in their time seemed dominant*—which became extinct, and left no descendants whatsoever.

Of those that have come more or less to our attention, for example, there were such antique giants as the Uintatheres and the Titanotheres. And there were scores of others no less familiar to the paleontologist.

These were highly specialized races, dominating the ages in which they lived. They waxed mightier and mightier for millions of generations. And then—they vanished; not supplanted by their own descendants, modified by Evolution, but leaving no issue. Following the time of their supremacy there had come a time of decadence, race suicide became a threat and then an actuality And at last came a day when the final member of the clan died—and it was as if that race had never existed.

How are we to explain such a sequence of events? If such extinction of a race had happened once or twice, or a hundred times, it would not be worth debating. But it happened thousands of times—millions of times if you go back far enough. It is merely an epitome of the normal history of past races, not alone of mammals, but of their predecessors. Everyone knows, at least in outline, the story of the giant reptiles that dominated the earth for millions of years—and vanished.

Must the dominant mammalian race vanish also? That, really, is the interesting question that lies back of any inquiry as to *why* past races have become extinct. It is worth while, then, briefly to list the causes that have been suggested to explain the familiar facts of animal extinction

First naturally, one thinks of changing climatic condi-

tions. Explicitly one thinks of that recent event, the Glacial Epoch. It goes without saying that you cannot cover half a continent with a mile-deep ice-sheet without profoundly influencing the animal life of the remaining part of the continent. It is within the possibilities that glaciation, even so extensive as that, may not have exterminated a single species of mammal in its entirety. The ice sheet may have spread from the north so slowly that there was time for the normal emigration of species (not, of course, a conscious migration) to carry some members of every species beyond the danger limit.

But even in that event, the ultimate effect on the species might be no less disastrous. The evil day might be only postponed. In reality, it appears probable that the great glaciation of the Pleistocene—the "recent" Ice Age of which we are speaking—was the indirect cause of the most wholesale extermination of individual organisms and remarkable mammalian races of which there is geological record. It will precisely serve our present purpose to attempt to visualize the conditions attending that great mortality, and, in imagination, witness the scene of slaughter.

Recall, then, that (according to the conception of continental drift outlined in an earlier volume) the portion of Holarctica called North America had drifted so far to the north that Greenland centered over the Pole, and the upper border of present Florida and the Gulf of Mexico was at about the fiftieth parallel of latitude. The ice-sheet, at its maximum, extended well below the sixtieth parallel, outside the Arctic Circle, into the heart of the Mississippi Valley—the region of present Missouri. The territory that remained for animal occupancy included part of Alaska, the Pacific coast region, Mexico,

and the southern moiety of the central and eastern States. Only a fraction of this region lay south of the fiftieth parallel—the latitude of the present western border between the United States and Canada.

These geographical details must be clearly understood, in order to appreciate the climatic conditions of the environment into which the erstwhile northern population had been gradually thrust. Even if we ignore the refrigerating influence of the ice-sheet at the north (which cannot have been negligible, but was subject to extreme fluctuations), we must assume that the climate averaged cold-temperate—ranging from subarctic at the north to warm-temperate at the southern extremity of Mexico.

Imagine, then, that into this restricted region of dubious climate there is crowded an animal population that would make the present fauna of central Africa seem impoverished by comparison No such wild menagerie was perhaps ever before or since collected within corresponding geographical limits Here were perhaps six or eight species of elephants—several mastodons, the gigantic Columbian elephant and the even more gigantic imperial elephant, and possibly some few thousand mammoths There were times when elephants wandered in herds that find a modern parallel only in the herds of bison of our Great Plains of a half-century ago.

Bison were there also, competing with the elephants for pasturage; bison ancestral to the modern ones, and others of larger size, with portentous horns almost rivaling the tusks of the mastodons. Then, too, there were gigantic camels; the herds of horses of several species, some of them larger than modern draft horses; also deer, and moose (and a strange deer-elk), and caribou, and musk-oxen, and peccaries, and tapirs, and —lest any

scrap of vegetation should escape—hosts of rodents of every size from jumping mouse to giant beaver, with legions of gophers, squirrels, woodchucks, and rabbits between.

And at that we are overlooking the most massive vegetarians of all, next to the elephants—the colossal ground sloths, of several species; and their great cumbersome shell-covered cousin the glyptodont, most incredible of mammals; and that other cousin, only less bizarre, the ant-bear.

All but the last-named of these are vegetarians. Needless to say, there was a coterie of killers to match. At their head was the massive saber-tooth cat, with fangs justifying his name; yet, even so, doubtfully supreme in the presence of the largest lions that ever existed. The dire wolves, too, were but a shade less formidable; and there were gigantic bears of several species, and pumas, jaguars, and lynxes that would seem quite menacing enough in any lesser company.

In a word, here was a galaxy of plant-eaters such as no territory of restricted size could possibly maintain, even under tropical conditions—which did not obtain. And a company of killers whose appetite for flesh could not long be appeased unless the census of their victims was maintained at maximum.

The outcome was forecast in the conditions Such a population could not be maintained.

To make bad matters worse, the land surface to the south and west was being slowly elevated, and becoming progressively more arid. A climate already too cold became colder, because of the elevation. Forests disappeared, and only such of the vegetarians as had developed teeth enameled for grazing had a chance to hold their own. This shut out the mastodons, but left the true

elephants in competition with the horses and deer and bisons.

Now, however, size became even more significantly a factor of survival Size and speed—to enable the grazer to seek distant pastures. It was one thing to require ten pounds of fodder in a day; quite another thing to demand a hundred. And if the small feeder has a range of fifty miles a day, while the large feeder can travel only twenty miles, the issue is still more clearly defined So as between elephant on one hand and horse and deer and bison on the other, you can foresee the decision.

Yet another factor Consider the matter of fecundity. An elephant takes fifteen or twenty years to reach breeding maturity. A deer requires only one or two years And the elephant has one offspring at a birth; the deer usually two, and sometimes three. Reckon the difference, in the course of, say, a hundred years, or a thousand. At best, only a small company of elephant progeny; of deer descendants, thousands or millions. And each one a potential eater of herbage that the elephant must secure —or perish.

And so of course the elephant herds dwindled and vanished And with them went the camels, the biggest moose and bison, and—naturally—the great sluggish ground sloths and the shell-backed glyptodonts And, just as surely, even if perhaps not quite so soon, there vanished also the monster cats, whose bulk and strength and dagger-teeth equipped them to pull down ground sloths and half-grown elephants—but handicapped them in the pursuit of agile deer and horses

There is a good deal more to the story. But for the moment let us leave it here—at the stage of vanishment of the giants As the story has been told, it has been made to appear that the very bulk of the colossal mam-

mals was the cause of their undoing. The defense mechanism, Size, which made possible their evolution, was their ultimate Nemesis. And that, essentially, appears to be the truth of the matter. Specialization in size, to meet certain conditions, spelled disaster under changed conditions.

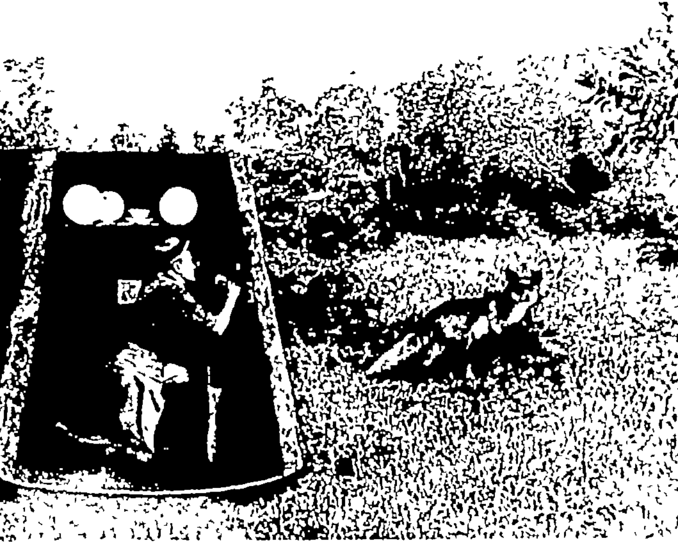
But are we to interpret such a sequence of events as showing that specialization was inherently a mistake? Do we here find evidence, as some biologists would contend, of racial decadence, necessarily sequential to evolutionary development? Did the elephants perish because they were, as a race, old and senescent?

If the story of the extinction of the elephants, as above outlined, is valid, these questions answer themselves. There is no evidence here of racial decadence. No suggestion of proof that the augury of extinction is inherent in the process of evolutionary development. In a word, no suggestion of evidence for the contention that extinction is inevitable for any animal race. Under conditions of stress that were without precedent, the elephants that had thrived in America were no longer able to exist in America. But that by no means proves that the same races might not have continued to thrive here, had conditions suitable for their maintenance continued as they once had been.

The fact that collateral descendants of the extinct elephants found—in India and Africa—environments to match the old ones, and continued to maintain their race to this day, sufficiently answers the thesis of inherent racial decay through overspecialization. The fact that the wild horse also became extinct in the Americas, yet subsequently, when reintroduced by man, throve and flourished abundantly in the same regions from which it had earlier been banished, refutes the thesis of racial

senescence from another angle. But other factors are involved in the story of the passing of the horse, which call for consideration in a separate chapter.

Suffice it here to answer the question with which this chapter started, with the categorical answer: We find thus far no evidence to show that the extinction of any animal is inevitable. There is nothing thus far in the evidence to show that a race of animals, however specialized, might not survive indefinitely, *granted favorable conditions*. Does the italicized proviso seem to hedge the question after all? Well, let it go at that for the moment.



HUNTING WITH THE CAMERA

SURVIVORS MUSK-OX — BISON

XIV

EVOLUTION AS NEMESIS

WE have removed the elephants and ground sloths rather summarily from the American scene, but there remains a varied company of mammalian contestants. And there is more than one member of the company that is threatened with the fate that befell the departed giants. Nor will mere size be the criterion by which the remaining contenders for a place in the sun will be primarily tested. No single cause operates for the building up of any organism, nor for its destruction. The problem of animal extinction is not so simple as that would imply. We have now to glance at certain other salient factors

By way of forecast, let us note certain anomalies that call for explanation—if explanation can be found There was, for example, the matter of the disappearance of the wild horse from America, just referred to incidentally. The horse's American lineage, as attested by authentic fossils, dates back to the Eocene. If any higher mammal is a one-hundred-per-cent American, it is he. Yet there probably was not a single horse alive in the western hemisphere when Columbus came so near to discovering our continent. Why this banishment of the horse from his own ancestral manor?

Then, from a different angle, consider the case of the opossum, and the even more anomalous position of the Canada porcupine. Both these animals appear to belong in South America, or at least in tropical Central Amer-

ica, with their hosts of relatives. Why have they alone, of their respective tribes, remained in the north? Again, if mere bulk is a handicap, how does it happen that, in the final reckoning, we find the moose, really gigantic for a deer, and the musk-ox and the bison still with us; while numerous herb-eaters a fraction of their size have vanished? And how does it happen that the polar bear and the grizzlies, among the very largest Carnivores that ever lived, are today thriving, while countless small wolves and foxes and cats that were their Ice-Age contemporaries long ago joined the majority?

Let me hasten to say that I do not profess to be able to answer all these questions—or any one of them—except inferentially. I cannot even tell you with confidence just why the passenger pigeon has become extinct in our own generation—under our very eyes. So I shall not pretend to know *all* about the whys of animal extinctions that took place millions of years ago; nor the correlative whys as to the preservation of allied races. But I think we may perhaps gain some clues to principles of action—of so-called animal "ecology"—or at least half-explanations of these mysteries, by following a little farther in imagination the fortunes of the animals of the Ice Age, with occasional glimpses of the lives of some of their forebears

Consider, for example, the situation of the horses, browsing and grazing across territory that their ancestors had trod for millions of generations. The earliest of these ancestors that is definitely known to us as such was little Eohippus, the pro-horse of the Eocene. His remains are found in the Wasatch fossil beds of Wyoming. Progressive intermediate forms left their records in other fossil beds of the neighboring regions There were wanderers of the clan, of course. Some spread to Asia at

the west; others to Europe at the east; still others emigrated southward to the other hemisphere. But the point of present interest is that the direct ancestors of the horse of the Ice Age had been habitants of somewhat the same territory throughout their racial history, since the Eocene, or the very early part of the Tertiary period.

Note now that in the Eocene time in question, the territory that is now Wyoming was not located (according to the theory we are following) at about the fortieth parallel of latitude, where it now is; but very far to the south of that, well within the tropic zone. Recall that the northward drift had been very slow indeed, so that the mid-period at least of the horse's evolution had been reached before this region had advanced into the cold-temperate zone Moreover, the later generations of developing horses had been able to emigrate toward the south, and thus to keep within the warm temperate zone, or even the subtropical The largest of the true horses of the Pleistocene left their bones in Texas—*still crowding toward the warmer zones of their* habitat.

It appears, then, that the horse was a creature of tropical and warm-temperate antecedents, so to speak. It had been specially modified for existence in plains regions, partly arid, where grasses grow, and where the climate is fairly mild. It was in no wise fitted to "rough it" with the musk-ox and caribou, or even with the prosperous newer immigrant, the bison. Yet now it was called upon to meet such competition. The difficulties were almost insuperable It was bad enough that the erstwhile well-sunned region had been thrust northward into far colder zones. But that handicap might perhaps have been overcome, had not the plant-eaters of the north—deer, moose, caribou, musk-ox—been forced to

invade the territory. And to cap the climax, herds of bison from Asia came as a devastating horde, demanding all the pasturage for themselves. There were even mountain goats and bighorn sheep that were often driven from the mountains by local glaciers, and obliged to forage in the already crowded pastures

The multiple handicap was too much The horse is a slow-grower, and at best not a prolific breeder Breeding does not ordinarily begin till the third or fourth year, the gestation-period is eleven months In the replenishment of numbers that fall before the attacks of wolf and bear and wolverine and puma, to say nothing of natural mortality from exposure or food shortage, the horse could not compete with even the bison, let alone the deer and prong-horn

Of what avail that the horse was the most highly specialized runner in the world—the only creature (save one) with the foot mechanism evolved to the single-toe stage of maximum running efficiency—if there was no untenanted grazing field to which to go? The nervous organization that gave quick reaction-time, for speed and endurance, was worse than useless when what was needed was toughness of fiber, and capacity to withstand cold and snowstorms The sluggish musk-ox, with its shaggy overcoat and sharp horns for defense, was to be envied.

No need to prolong the story The horse vanished And so did every other creature that was not adequately equipped to withstand the rigors of a cold-temperate climate—except the few that were lucky enough to emigrate down into Mexico and Central America, and that channel of escape was not always available, owing to intervening deserts and mountains The net result was that, by the time the ordeal was over - the ice-sheet

melted, the continent swung back a little nearer the tropics—there remained of all the vast and varied cohorts of the pre-glacial epoch only an "impoverished remnant," to constitute the mammalian fauna of our own time.

And of that sparse band of survivors, there is not one that did not develop sufficient ruggedness to enable it to live in the cold-temperate zone. As the ice-sheet finally vanished, the old-timers of the Arctic emigrated slowly back again to the north, or went back to the mountains. Their descendants of today are the musk-ox and caribou and arctic hare and arctic fox and polar bear of the far north; and their like-minded former associates the bighorn and mountain goat and hardy pika and mountain beaver of the alpine heights of the Rockies and Sierras. Any members of these heavy-haired fraternities that attempted to maintain existence at the south, after the Ice Age, found themselves as unfitted for competition there as their less hardy confrères would be to compete with them in their polar environment.

And yet, as has been said, even the least hardy of the survivors (overlooking for the moment the few that escaped to the tropics), had proved by the very fact of their survival that they could cope with the conditions of a cold-temperate climate. And to this day there is not one of them that has not representatives living as far north as the Canadian border—even tho having other representatives that have proved their adaptability by becoming acclimated in warmer regions of the United States. I speak now, of course, of families of mammals, not of individual species or geographical races The point is that the animals that survived the glacial ordeal were able to live in the cold-temperate zone, else they would not have *survived.* And their descendants are

still able to live, for the most part, at least as far north as the present region of the fortieth-to-fiftieth parallel, where the present climatic conditions more or less duplicate those of the average terrain of their glacial epoch experience.

As illustrations, it will suffice to mention such familiar Herbivores as the moose, the wapiti, the white-tailed and black-tailed deer, the bison (the only remaining wild herd is in British Columbia), the porcupine, the beaver, and sundry hares and rabbits—not to overlook the small-fry moles, shrews, mice, and squirrels. Their carnivorous complements equally in evidence are, among others, the puma, the black and grizzly bears, the wolverine, the lynx and bobcat, the timber wolf, the foxes, and the weasel allies, including marten, fisher, mink, and otter.

But where, in all this, is there application to the theme we are supposed to be following? What is the application to the chapter title: "Evolution as Nemesis"?

Let us look a little closer The application is not far to seek It is in part revealed if we recall that the various races whose obsequies we have celebrated — the elephants, ground sloths, horses, and the rest — were doomed by the very excellence of their adaptation to certain conditions, and that Evolution was the artificer of the adaptation The very essence of the evolutionary process is such adaptation. One animal is adapted for life in trees, another for underground life; another for speed along the ground, yet another for life in the water. And the more perfect the adaptation, in each case, the more complete the unfitting for any life other than the one chosen

The best that Evolution can pretend to do, then, is to modify an organism to meet the needs of an *existing*

PREDATORY SURVIVORS: WEASEL AND MINK

environment There can be nothing prophetic about the modification Should environmental conditions suddenly change, the adaptation will prove not merely futile, but almost certainly harmful

It is only the unmodified, generalized form, seemingly neglected by Evolution, that is fitted to live *fairly* well in every environment, because it is fitted to live *supremely* well in none

Go a step farther. The environment is always changing It cannot be otherwise in a world in which continents are being perpetually made over—whether or not you admit that they are changing their locations It is no theory, but undisputed fact, that geological climates have been incessantly modified A region that grows palms today grows oaks tomorrow, and only grass the day beyond—geologically speaking. So there is nothing more certain than that when Evolution modifies an animal to meet existing conditions of the moment, Evolution is preparing that animal for future disaster. The more complete the adaptation or specialization, the more impossible will it be to change the species to meet radically changed conditions. To meet those new conditions, material on which Evolution is to work must be sought in the primitive, unspecialized forms, which have previously been ignored.

That is the unvarying history of animal evolution. The new strain from which the higher and more specialized form of tomorrow is to be evolved, is found always in the small, unspecialized race of today. The highly specialized race of today will presently be superseded by this parvenu

But even if we take a less extreme case, and suppose that the environmental change is very slow, and that the specialized race can be modified to meet the new

conditions—none the less true is it that the creature of the earlier specialization must be superseded by its grandnephew—to the millionth generation removed—and hence just as truly become extinct. For a long time the earlier adaptation and the newer improvement may exist side by side—but ultimately the older and now less perfect form vanishes.

Is the application clear? In each case, and however often the theme is reenacted, Evolution has worked to produce a modification that must soon become as obsolete as the ox-cart in the age of the automobile. In other words, Evolution develops a race only to have it superseded by another product of Evolution.

Thus Evolution acts with one hand as creator of species—and with the same hand and by the same act, becomes the destroyer of the species created yesterday.

That perhaps clarifies what I had in mind when I spoke of "Evolution as Nemesis." But the explication does not bring us quite to the end of what I wish to say about the rationale and bearing of the evolutionary process. Turn we, then, to another aspect of the problem of living, in the ensuing chapter

XV

SUBTLE ENEMIES

EVERYONE has heard that there are regions of Africa where horses cannot live, because of the tsetse fly It is well known, too, that it is not the direct attack of the fly that is fatal. The menace lies in the activities of the microbe (called a *Trypanosome*) which the fly transmits from one animal to another. This parasite flourishes in the blood of the horse, and causes the death of the animal. Yet there are numerous antelopes and other animals of the region that are immune to the malady. The *Trypanosome* cannot flourish in their systems

Such discrimination as that, on the part of microbic organisms, is not at all unusual. The germ of hog cholera may ruin the hog-raising industry in a region, but has no effect on cattle, sheep or horses. The cattle tick of Texas is a famous carrier of germs to bovines, not to horses There are regions of New England where sheep-raising was given up because the soil appeared to have become impregnated with bacterial germs that menaced sheep, but no other domestic animal. In other regions, turkey-raising was abandoned for a similar reason.

The malignant germ of the newly-recognized malady called tularemia is carried by the rabbit. Rats and ground squirrels harbor the flea that transmits one of the most menacing of human plagues. There are contagious maladies that sweep off whole populations of domestic fowls It is suspected that the germs of one of these

EXTINCT PASSENGER PIGEON — EXCEEDINGLY ABUNDANT TILL LATE IN 19TH CENTURY

maladies was transmitted to passenger pigeons that were caged, and subsequently used as targets at pigeon-shoots An occasional pigeon escaped the gunner, and the malady may have been thus transmitted to the wild birds, with the result that the passenger pigeon, which a century ago was among the most abundant birds in America, became extinct, with spectacular suddenness, toward the close of the nineteenth century But the mourning dove, which is close kin to the extinct species—so similar in appearance that only the trained eye could discriminate between the two at a little distance—is still abundant.

It is by no means certain that this explanation of the disappearance of the passenger pigeon is the right one But it is not unplausible, in view of the discriminative nature of microorganisms Such discrimination, indeed, is the rule, not alone with the agents of animal diseases, but with those that menace plants as well. The fungoid blight that was introduced (needless to say, by accident) from China, in the bark or wood of imported chestnut timber, has given in recent years a quite amazing demonstration of selective affinity for one kind of tree only. It leaves no chestnut tree alive, and yet has no influence whatever upon any other species of tree.

Spores of this fungus float through the air, and must settle on all trees alike. But only when the accidental host is a chestnut can it live and grow. So you may see blighted chestnuts by thousands scattered through the woodlands of New England, or any other region within a few hundred miles of the original source of distribution, the port of New York. The woodland may contain oaks, maples, ash, hickory, birch, hemlock, and all the rest—and not one is injured. There may be fifty of these various immune species to every single chestnut--

but the one chestnut is singled out inexorably, and presently stands bare, the bark fallen away from its dead trunk and branches, a grim skeleton in the midst of the sea of verdure to which it formerly contributed.

The case of the chestnut is so tangible that it cannot be overlooked. But animal life of the forest, if we could witness it, would reveal many similar tragedies. Recently some unknown malady killed our ruffed grouse almost to the last bird. And epidemic maladies that decimate the rabbit population are of perennial recurrence. Meantime numberless parasitic insects contribute to the harassment of every animal tribe, and, directly or indirectly, exact a high toll of victims.

The menace of the insect hordes is by no means confined to their direct aggressions. There are thousands of species of insects, any one of which has potentialities of increase which, if unchecked, would enable them to overwhelm entire animal populations, by stripping bare the vegetation on which the animals feed. The locusts that now and again—within the memory of the present generation—have swept across the western plains and prairies, leaving no green thing in their wake, illustrate the possibilities of multiplication that are inherent in every insect race. The little green aphid on yonder rose-leaf, if its progeny could develop unchecked, and find food, would produce in one year (as Huxley estimated) a bulk of aphid-flesh to outweigh the total human population of China. And of course that would be only the beginning. Given another year or two, and they would bury the surface of the globe to the depth of millions of miles.

The case of the grasshoppers shows that insect potentialities may now and then become realities, for a few weeks at least—long enough to enable them to trans-

form rich wheat and corn fields and abundant meadows into arid deserts. And the insects are no new invention. They came in full force back in the Mesozoic era, and had a share in the development of the flowering plants. Can we doubt that on occasion they erupted in hordes, and destroyed the vegetation on which the animal populations of the past epochs subsisted?

It is quite within the possibilities, then, that bacterial germs of disease, on one hand, and insect pests, on the other, may have had full share in the extermination of the animal races whose passing we have witnessed. The competition of these midgets may have been the determining factor in the removal of the elephants, the horses, and all the rest. Such possibilities must be considered, if we would attempt to gain a comprehensive view of the factors that operated to undo the work of Evolution in developing new forms of life.

But of course we shall not overlook the paradox that it was Evolution, again, that developed the devastating microbes and insect pests, no less than their victims.

There is still another factor to consider, if we are to box the compass of the problem of animal extinction. We must look to the soil itself, out of which vegetation springs. We must recall that plant life exacts perpetual toll of chemicals from the soil, and the supply is never inexhaustible. The elements prominent in the composition of the basic life-substance, protoplasm, are relatively rare elements. And some of the chief constituents of bone and teeth are excessively rare—in the comparative scale. Phosphorus in particular, which enters into the composition of protein as well as bone, is present in the earth's crust in very limited supply. Lime is more abundant by far, but is subject to being leached from the soil by seeping and running water.

These are very elementary truths, familiar to every tiller of the soil (in general terms, if not as to chemical technicalities) at least from classical antiquity. No farmer needs to be told that he cannot continue to grow good crops without restoration of depleted elements by fertilization But we do not always stop to reflect that the same principles of soil exhaustion through leaching apply to wild pastures; and that the grazing populations do not restore to the soil immediately all the essential elements that they remove and store in their bodies.

Take the matter of phosphorus as an illustration. Bones and teeth are composed largely of phosphate of lime. The carcass of an elephant stores a ton or several tons of this substance And stores it permanently, while the animal lives, and for centuries or millennia afterward. The great bones do not instantly crumble. They lie bleaching or buried for the lifetime of many generations of the elephant's descendants. Is it not possible that the land where these generations forage may become depleted of phosphorus, to the point where the supply is inadequate to make proper skeletons and teeth for the animals of the later generations? If so, these animals must emigrate, or perish. And this necessity might come while still enough of the essential elements remained to supply adequately the needs of smaller animals. A million mice require no more bone-material than a single elephant. It is even possible that creatures as big as the bison (particularly creatures of cursorial habit) might find bone material enough, while the elephants and ground sloths suffered from phosphorus-famine.

A slight extension of the same line of thought brings in the Vitamins and Hormones—those elusive catalysts upon which the operation of the entire life-mechanism depends, yet whose very existence was not suspected

until our own generation. Now the physician recognizes "want" diseases among the commonest and most baleful of maladies. A shortage of iodin causes the thyroid disturbance called goiter. A shortage of manganese disturbs the functioning of the adrenals that control circulation of the blood. A magnesium shortage causes sterility. Two minute glands in the neck—the parathyroids—must function properly or the system cannot make proper use of calcium for bone-building, even if plenty of calcium is ingested.

Such intimate and subtle relations between chemicals (some very rare, like iodin) and the vital functioning of the animal organism were unsuspected by the physiologists of yesterday. What we are coming to know—mere glimpses into the vast field of the unknown—tells us that the varying chemical constitution of the soils may quite possibly be, not merely one feature, but perhaps the most salient feature, in determining the rise and fall of animal races.

It is well within the possibilities that the great Titanotheres, for example, died as a race—an entire Order of giants—not because of changing climate, or competition of animals of collateral lines, or insect pests, or bacterial diseases—but because the soil of their habitat had become exhausted of, say, iodin or phosphorus, or perhaps some other element whose relation to the growth and health of organic tissues we do not even now suspect.

All this is highly theoretical, of course. But it is surmise based on observation of the physiological and pathological conditions of living creatures of today, including our own species. And it gains plausibility from the reflection that we have every reason to believe that the same principles of life have applied to every generation of organic beings throughout the geologic ages

SURVIVORS· CANADA PORCUPINE (DEFENSE MECHANISM)

OPOSSUM (HIGH BIOTIC POTENTIAL)

XVI

THE "BIOTIC BALANCE" AND HUMAN PROGRESS

THE one tropical animal that seems misplaced in the North American fauna is the opossum. This animal alone of those that survived the great mortality of the Ice Age has been unable to extend its range into the Canadian zone, and yet manages to live well above the fortieth parallel More than a score of its close cousins live in Central and South America. Their escape from extinction is explicable: they were able to retire to a climate suited to their racial needs But how account for the survival of the Virginia opossum, which sometimes is found as far north as New York?

The answer is given—or at least a part answer—by such a photograph as you have doubtless seen: a picture showing a dozen or more cunning youngsters clinging to their mother's back, their tails perhaps twined about hers. An even more convincing answer, along the same lines, is furnished by the anatomical report that an opossum has been known to have twenty-five teats—providing for an even more preposterous family. Such fecundity as that implies is rivaled by no other known mammal. The little tenrec of Madagascar (an Insectivore) has a record of twenty-one young at a birth It appears that the opossum might on occasion surpass even that astounding exhibition.

But even if we consider only the opossum's average family of, say, ten or a dozen, we have to do with powers

of reproduction of rather appalling potentialities. However near the opossum tribe might be brought to extinction, one or two surviving pairs could very soon repeople a continent. *If* there were no opposition.

Of course that is an impossible "if." But the principle of rapid extension of population under average conditions of adversity holds; and it was probably the opossum's capacity to rise to the occasion in the manner suggested that was the determining factor in staving off what must at times have seemed inevitable race extermination.

Even after the period of greatest competition, during and after the Glacial Epoch, was over, times were never too easy for a largish, rather unintelligent, sluggish, mainly defenseless creature like the opossum. So the high birth-rate continued to be of service, and Evolution did not find it necessary to modify the opossum's fecundity, as the fecundity of most larger mammals was modified.

As to that point, a word of explication is perhaps desirable. The reptilian ancestors of the mammals were excessively prolific, as egg-layers are wont to be. And doubtless the earlier mammals retained something of the prolificness of their ancestors. The fecundity of the primitive types of mammals, like Insectivores and Marsupials (of which tenrec and opossum are examples) to this day is suggestive. But as mammals advanced in size and capacity for meeting life's emergencies, it became expedient to curtail their individual birth-rates in the interests of the species involved. For the most active competition that any animal experiences in the Struggle for Existence is likely to come from members of the animal's own species—whose food habits are of course identical.

Hence it becomes expedient to experiment with the

number of offspring to be borne at once, and the frequency of litters, to find out what is the happy mean between overpopulation and race suicide. The balance must often be very delicately adjusted. Endless generations of experimentation must have been required. Doubtless there were thousands of species that disappeared, because the test was carried a little too far under conditions more favorable than those that subsequently obtained.

But in the end, every species that became and remained prosperous had been so adjusted that the balance between its birth-rate and its average death-rate, over a reasonable period of time, was slightly in favor of the births as against deaths. Such an adjustment was obviously absolutely essential. And it is almost a truism to say that the adjustment was made on that basis for every species that was to persist.

But the vicissitudes of life are so different for different species, that the *actual* birth-rate might vary within rather wide limits. The opossum, as we have just seen, must bear a dozen or so offspring on the average, in order to match the death-rate of its species. If its average were to drop to, say, five, for any considerable period (unless the hazards of life very materially bettered), there would soon be no opossum left in the world. But meantime the Canada porcupine (which, like the opossum, is the sole northern survivor of a tropical family) has so much less hazardous life—owing to its matchless defense mechanism — that it can afford to restrict its average family to about two offspring (with four for maximum), and yet continues to thrive as a species.

And the bat, which has the perfect defense, finds life so unhazardous that Evolution has taught it how to practise birth-control to the extent of limiting its quota

to two offspring, or even a single one, and thereby so adjusted the relations of the life and death issue that the bats have prospered amazingly, and spread their habitat round the globe.

The opossum, with its family of twelve or fourteen, has barely been able to hold its own in a limited territory of the eastern United States. The bat, with one or two offspring to carry on the tradition, has spread across all zones and continents. Obviously, then, the birth-rate *by itself* is no criterion of prosperity. We may well believe that if the bat were to increase its average family to three, even, the competition through overpopulation would soon be so great that bats would be running afoul of one another in the air, and perforce practising cannibalism in the attempt to escape starvation.

I cite these random specific instances merely to give point to the brief general analysis of the matter of birth versus death in the animal world that I wish to make by way of summary of the subject of the Balance of Nature which has been, in effect, the theme of all our studies of animal life. The examples of extinct forms of life, and the suggestions as to possible causes of extinction, have been designed to lead to the same end. All that is now required is to state in general terms the simple principles that appear to be involved, the unity of which might perhaps escape observation because of the varied aspects of their exemplification in particular habits of diverse species

In a nutshell, the whole basis of the evolutionary process—whereby races have been developed, and modified and differentiated, and specialized and exterminated—is this:

The future of every species of animals, estimated at any given time, is conditioned on the relation of its birth

rate to its mortality rate, over a brief series of generations Otherwise stated, the potential fecundity of the species, as measured against the actual average death-rate, determines whether the species is numerically expanding or declining, or remaining stationary. And for an animal species in a state of nature, a declining population involves grave hazards

A recent writer, Dr Royal N. Chapman, has put the matter succinctly, in technical phrase, by calling the birth-rate of any species its "biotic potential" (capacity for increase of population if unopposed), and summarizing the hazards of life that account for the death-rate under title of "environmental resistance." The new terms have value in aiding one to visualize *en masse* the conditions involved in what is commonly spoken of as the "Balance of Nature." Every fact of habit or circumstance of animal life that we have had occasion to examine in the successive chapters of this book may be classed under one or the other of these alternative headings

The whole story of animal life, past or present, is a story of the *biotic potential* versus the *environmental resistance*, of individual or collective species.

Less technically stated, it is a story of the *Urge to Live*, hampered and perennially checkmated by the *Impediments to Living*.

The varied ways in which the urge manifests itself, and the numberless expedients by which it is sought to overcome the impediments need not be recapitulated here. Nor do I suggest that the new names just cited add any essential to the simple thesis that every animal mechanism has been evolved as an aid to its possessor in the struggle to maintain life and perpetuate its kind. The old Darwinian phrases, "Struggle for Existence" and

"Survival of the Fittest" are merely restated by the new terms. Yet a restatement often has great value, in giving a view of an old field from a slightly different angle.

In any event, my present purpose, in presenting the new terms, was to make tangible an application of the whole evolutionary story to the biotic conditions of our own race. We, too, are mammals, and no forced analogies are called for in making such an application. It is just as true for the human race as for any other, that the balance between "biotic potential" and "environmental resistance" must determine the issues of race-maintenance and progress or decay.

But while this is obviously true, it is also true that the conditions by which the terms of the declaration are to be interpreted have changed. The difference is this:

Man's intelligence has placed him in position to do two fundamental things that no other mammal has been able to do—no other *mammal*, I say; note the word. These things are: (1) Control of the biotic potential, and (2) Essential control of the environmental resistance.

In other words, man can change the essential conditions of the entire life problem, as it has confronted the mammalian world from its earliest development to the present hour. Evolution changed the biotic potential of mammalian species by slow gradations to meet ever-changing needs. But no species at any time had voluntary control over that potential. The urge to procreate was as imperative as the urge to breathe. Even tho increase of population, under changed conditions, would spell death for the species, the members of the species had no power to hold population in check at the source.

It is true that the social insects learned how to do this. Bees and ants can and do regulate their population,

to meet the changing needs imposed by changing environments. But man is the first mammal who has attained the insect standards of intelligence for the meeting of such an emergency.

As to the other side of the equation. It needs no telling that no mammal has ever developed the intelligence to exercise, even in the smallest degree, control over the environment in which it found itself. The beaver is perhaps the one mammal in whose favor a slight exception must be made. The beaver does build a dam and make a home that protects his family in a measure from environmental resistance of every type, including, for example, drought, cold weather, and the direct attacks of wolves and pumas.

But this partial exception only emphasizes the contrast between the conditions of life under which mammals in general live, and those under which man lives.

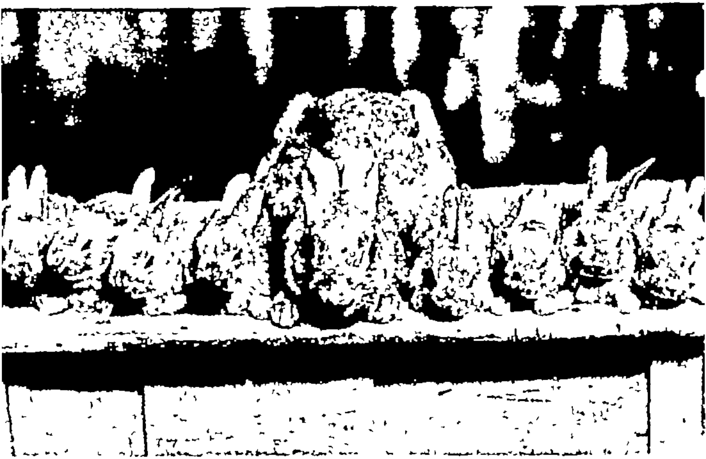
Man makes his own environment. If food is lacking, he cultivates soil, and secures the food. He domesticates animals and finds workers to help him, and new food supplies. And this is only the beginning. He harnesses the forces of nature, and makes light, heat, electricity work for him. In a word, his environment is under his control, to an extent that could never have been predicted as possible from observation of the history of any other race of beings—even the insects.

And that, in effect, is what I wished to say by way of interpretation of the formulæ that have determined the evolution of animal races, from Monotreme to Man. I have pointed out that there is no evidence for the suggestion that any race, as such, becomes decadent. I now point out that man is measurably free from the ancient handicap of the fatality involved in the necessity of every mammal to increase its kind at a geomètrical ratio,

regardless of the need; and the certainty of becoming out of step with its environment, when the environment changed.

The old conditions do not hold for civilized man. He has become in large measure master of the primal conditions that determined the evolution and the destruction of the races of the past. He is master of his own destinies, in almost the full meaning of the words. He need not be the victim of the old beast-laws of the Struggle for Existence and the Survival of the Fittest, unless he voluntarily chooses so to be.

In effect, he can substitute human intelligence, the highest product of Evolution, for Evolution itself as the determining factor in the future development of the highest mammalian product—his own species.



HIGH BIOTIC POTENTIAL

INDEX TO THE TEN VOLUMES

Roman numerals indicate volumes. Arabic numerals indicate pages.

The reader is referred to the Table of Contents at the beginning of each volume, as supplementing the Index.